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The SB70LC Development Kit

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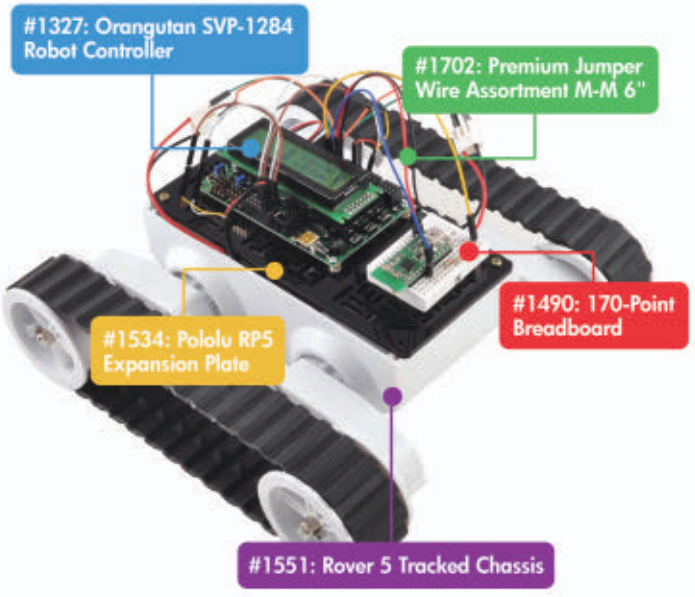
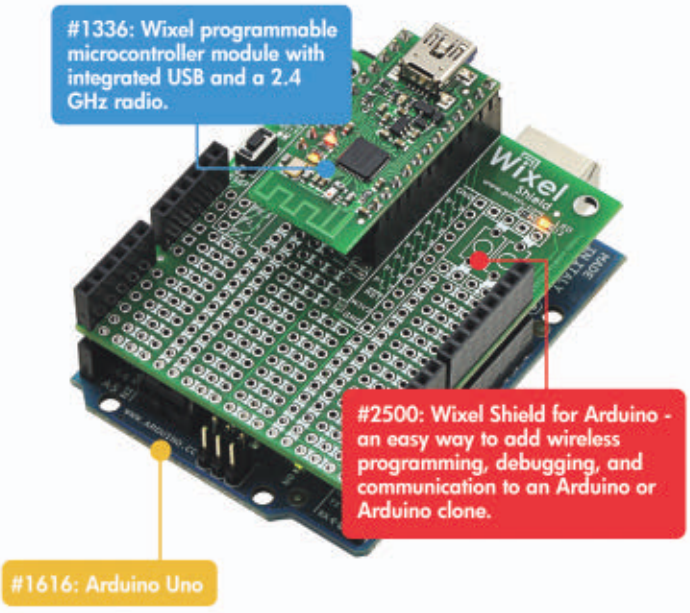
DIY Projects:

Simple Tracked Robot


#1327: Orangutan SVP-1284 Robot Controller
#1702: Premium Jumper Wire Assortment M-M 6"
#1490: 170-Point Breadboard
#1534: Pololu RP5 Expansion Plate
#1551: Rover 5 Tracked Chassis

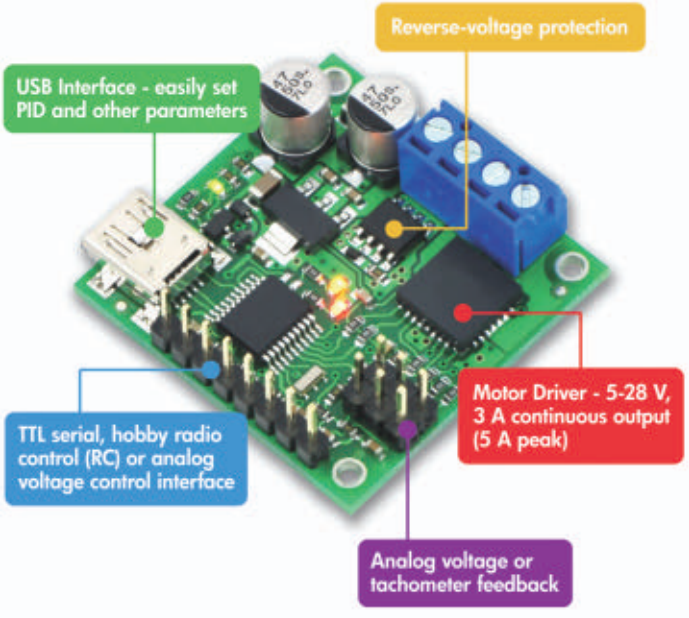
Programmable Controllers:

Wixel and Wixel Shield


#1336: Wixel programmable microcontroller module with integrated USB and a 2.4 GHz radio.
#2500: Wixel Shield for Arduino - an easy way to add wireless programming, debugging, and communication to an Arduino or Arduino clone.
#1616: Arduino Uno

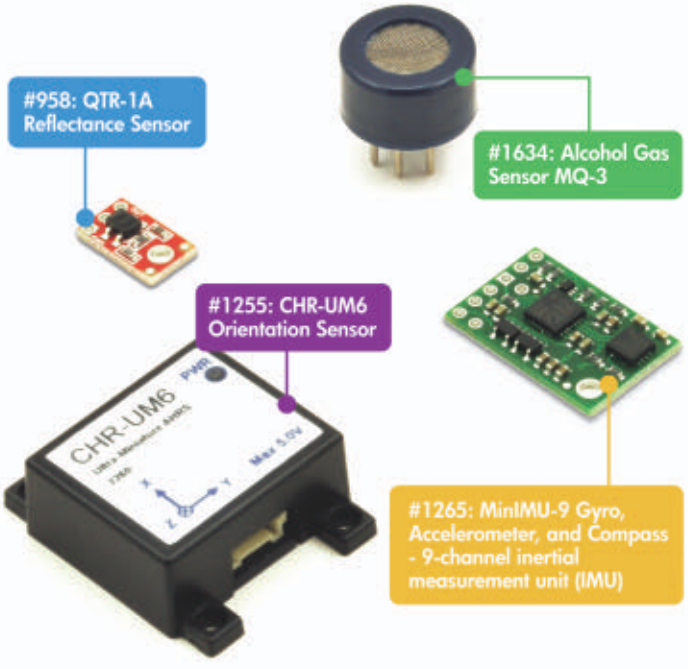
Motor Controllers:

Item #1392: Jrk 21v3 USB Motor Controller with Feedback


Reverse-voltage protection
USB Interface - easily set PID and other parameters
Motor Driver - 5-28 V, 3 A continuous output (5 A peak)
TTL serial, hobby radio control (RC) or analog voltage control interface
Analog voltage or tachometer feedback

Sensors:

Orientation, Reflectance and More


#958: QTR-1A Reflectance Sensor
#1634: Alcohol Gas Sensor MQ-3
#1255: CHR-UM6 Orientation Sensor
#1265: MinIMU-9 Gyro, Accelerometer, and Compass - 9-channel inertial measurement unit (IMU)

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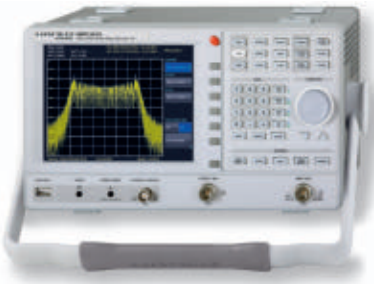

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Page 32

Projects & Features

32 Channel Surfing With An Arduino
The Arduino is perfectly suited to emulate the IR remote controls associated with many modern appliances. If your TV recorder and tuner are different devices, this will allow you to change channels between scheduled recordings on whatever schedule suits you.
■ By William Baird

38 The Edison Cell
Rediscover the secrets of a 100 year old "green" battery whose time may finally have come.
■ By Walter Noon III

44 Creating a Virtual Serial Port With the 32-Bit Micro Experimenter
Need a serial port but don't have one on your computer? No problem! We'll show you how to use your Experimenter to provide virtual serial communications.
■ By Thomas Kibalo

FUNdamentals For Beginners
76 Build a Moisture Detector

Departments

08 DEVELOPING PERSPECTIVES
30 NEW PRODUCTS
31 SHOWCASE
72 NV WEBSTORE
75 ELECTRO-NET
77 CLASSIFIEDS
78 TECH FORUM
81 AD INDEX

Columns

10 TechKnowledgey 2012
Events, Advances, and News
Read about a battery that offers a 25 year operating life, Clouds with ears, and seeing sound, to name a few. Plus, Pong turns 40.

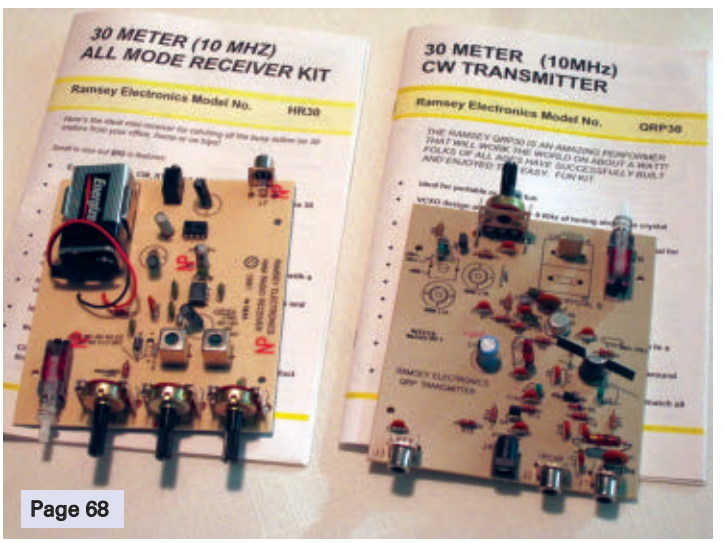
14 PICAXE Primer
Sharpening Your Tools of Creativity
Constructing a two-digit seven segment LED project board.

24 Q & A
Reader Questions Answered Here
Help with a random number generator, battery tester, LED dimmer, and a nonsense circuit are just some of the topics covered in this month's column.

52 The Design Cycle
Advanced Techniques for Design Engineers
CLC Culture.

59 Smiley's Workshop
Programming • Hardware • Projects
Breadboard LCD Navigator Part 2: The Navigator Buttons.

68 Open Communication
The Latest in Networking and Wireless Technologies
Comm Kits — A radio kit is a great way to get familiar with electronics and communications.



Page 68

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DEVELOPING PERSPECTIVES

How Do They Do That?

Reverse engineering is one of the most challenging and rewarding endeavors in electronics. I'm talking about replicating the functionality of a device that you've seen or read about but that's too expensive or otherwise unavailable. There are numerous issues involved in reverse engineering — from creating a schematic to locating parts. Moreover, you have to understand what's going on, both mechanically and electronically. In my experience, seemingly simple devices are often the most challenging. However, there are methods you can use to glean an understanding of just about any device on the market.

Case in point: I'd been lusting over a guitar synthesizer since it was introduced a couple years ago. According to the marketing literature, it was based in part on filter technology used in relatively inexpensive effects boxes. I managed to snare one of these effects boxes on eBay and — within hours of arriving — I had it disassembled on my workbench. Teardowns are one of the best ways of figuring out not only how a circuit works, but how to best assemble it.

Next, I searched for technical reviews that described how the synthesizer worked. As is typical, I had to piece together information from several reviews to get an understanding of the circuit and operating conditions. One article mentioned an external power supply, another special pickup designs, and so on. It seems that the marketing people for many companies won't divulge everything to one reviewer, but are fine with disclosing different aspects of their technology to different reviewers.

Armed with the information from the teardown and reviews, I started drawing up plans for a circuit board that I'd embed in one of my guitars. It wasn't much – a microcontroller, a few op-amps, a couple transistors, a 9V battery, and a handful of capacitors and resistors. Three weekends later, I had a circuit that checked out on my workbench. The next step was to test it with the guitar. Inexplicably, it didn't work. Electrically it checked out, and in side-by-side comparisons with the teardown, everything seemed in order. But there was something missing.

Perplexed and frustrated, I turned to my favorite source of technical information: the US Patent and Trademark Office (**www.uspto.gov**). If you've used Google, you know how to search the USPTO database. In fact, you can use Google's patent search engine (**www.google.com/patents**) instead of the USPTO site. Unless you need to run a complicated, multiple-keyword search, the Google site is a good first stop.

In the patent files, I located several patents that explained exactly how to integrate a synthesizer into the body of a guitar. It turns out that I got the electronics correct but I hadn't considered the magnetics. Specifically, the angles of the magnetic pickups used to capture the vibrations of the steel strings relative to each other are critical. In a typical guitar, the magnetic pickups are mounted parallel to each other and perpendicular to the strings. However, in this particular form of guitar synthesizer, the magnetic pickups operate best when the axes are about 30 degrees apart.

I hadn't thought of the magnetic properties of the circuit. However, thanks to information from the USPTO, I was able to align the pickups and test the circuit. Admittedly, my guitar synthesizer falls short of the real thing. That's something I'm willing to put up with, given my DIY guitar synthesizer cost less than one

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percent of the brand name device.

So, when that expensive high-tech device catches your eye, consider going DIY. If possible, get your hands on related technology for a teardown, hunt down technical reviews on the Web, and spend time reading through the USPTO's patent database. Then, you can make an informed decision about whether you have the skills and resources to replicate the device, purchase the device, or simply admire it from afar. **NV**

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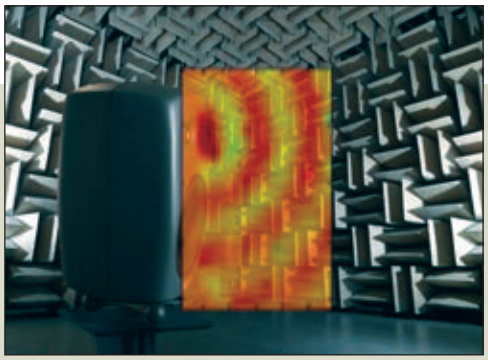
TECH KNOWLEDGEY 2012

EVENTS, ADVANCES, AND NEWS

■ BY JEFF ECKERT

ADVANCED TECHNOLOGY

SEEING SOUND



■ Laser-generated sound propagation map inside the NPL hemi-anechoic chamber.

Audio engineers are pretty good at designing loudspeakers that reproduce the full audible frequency range, but generating a smooth output in all directions is a challenge. The problem is the result of a phenomenon called deconstructive interference in which overlapping sound waves cancel each other out, creating dead spots. In the past, engineers have been able to create a map of the sound output's spatial distribution by using microphones to make high-accuracy measurements, but these measurements must be made at many points within the 3D space. An alternative is computer simulation of the loudspeakers' performance, but this has proven to be insufficiently accurate, primarily because of manufacturing process variability. Now, however, the Brits' National Measurement Institute (**www.npl.co.uk**) has come up with a way to apply laser technology to perform remote non-invasive mapping of sound fields. The technique should provide manufacturers with much better data to use for design purposes.

The NPL technique is based on an instrument originally developed to study mechanical vibration — the laser vibrometer — and makes use of the fact that the speed of light in air changes slightly when it passes through an acoustic field. This — known as the acousto-optic effect — causes a phase shift that the vibrometer can detect. In practice, all that is necessary is to position the laser beside the speaker and scan it through a series of points in front of it. The light is reflected back to the instrument by a retroreflective mirror and measured as it returns to the source. Finally, this information is used to generate an image of the sound propagation around the source. The bottom line is that engineers will find it easier to design dead spots out of tomorrow's loudspeaker systems. ▲

MATERIAL EMITS NEAR-INFRARED LIGHT

There's nothing unusual about materials that radiate visible light after being exposed to sunlight. Glow-in-the-dark toys and stickers have been around for many years. Until recently, however, scientists have been stumped in efforts to come up with a useful material that can emit light in the near-infrared range. In a recent paper, University of Georgia (**www.uga.edu**) Prof. Zhengwei Pan described a new compound that does exactly that. At its base is a well-known emitter called the trivalent chromium ion. When exposed to light, its electrons move quickly to a higher energy state. When the electrons return to the ground state, near-IR light is released. The problem is that the flash lasts only a few milliseconds.

Prof. Pan discovered that putting the material into a matrix of zinc and gallogermanate generates "traps" that can capture the excitation energy and store it for longer periods. Using a thermal process, the energy is slowly released back to the chromium ions over a period of up to two weeks, allowing it to provide continuous illumination. Just a one minute exposure to sunlight can create a 360 hour release of near-IR.

■ Night vision image of researchers Zhengwei Pan and Feng Liu standing in a room lit only with their near-infrared light emitters.

Potential applications are more profound than one might imagine. Most obviously, the material can provide military and law enforcement agencies with an invisible source of illumination for night-vision devices which is probably why the research was backed in part by the US Office of Naval Research. It also offers opportunities in biomedical areas. According to Pan, the material could be fabricated into nanoparticles that bind to cancer cells, allowing doctors to visualize the location of small metastases that otherwise might go undetected. In addition, "This material has an extraordinary ability to capture and store energy, so this means that it is a good candidate for making solar cells significantly more efficient." ▲

Discuss this article in the *Nuts & Volts* forums at http://forum.nutsvolts.com.

COMPUTERS AND NETWORKING

MOST POWERFUL ANDROID PAD

The Asus Eee Pad Transformer Prime is the first touch-based tablet to incorporate quad-core technology.

One of the latest tablets to be born into the Android world is the Eee Pad Transformer Prime, introduced last December by Asus (**usa.asus.com**). Emphasizing both power and style, the unit is powered by the NVIDIA® Tegra® 3 processor, making it the first tablet to offer quad-core technology. It also comes with a 12-core GeForce® GPU and virtual symmetric multiprocessing (vSMP) for speedy graphics and multitasking capabilities. Full 1080P HD video offers enhanced media and gaming performance. You also get a nice battery life of up to 12 hr, or up to 18 hr when used with the optional mobile dock. Other niceties include a 178° viewing angle on the 10.1 in Gorilla® Glass display, a 1.2 MP front camera plus an 8 MP rear one — the latter equipped with auto focus and an LED flash. Sound quality is said to be exceptional via the company's SonicMaster technology. In terms of style, we're talking about a case that is lighter and more compact than either the iPad 2 or the Samsung Galaxy Tab 10.1, coming in at 1.29 lb (0.58 kg) and only 8.3 mm (0.33 in) thick. You have a choice of two somewhat foofy colors, dubbed amethyst gray and champagne gold. If you were imagining that all of this comes at a cost, you were right. The list price is $499 for the 32 GB version and $599 for the upgrade to 64 GB. The dock will run you another $149. ▲

CLOUDS WITH EARS

On the software front, one of the most notable new concepts takes the form of MediaMined™ — a joint development from Imagine Research (**www.imagine-research.com**) and the National Science Foundation (**www.nsf.gov**). According to Imagine, this MediaMined is "the world's first sound object recognition web service. MediaMined identifies and labels sounds, making media files searchable and adding a set of ears to cloud computing." The patent-pending concept is a response to the realization that search routines are pretty good at finding text-based materials but very bad at pulling up audio and video files. If an A/V file isn't tagged with the appropriate keywords, it may essentially disappear.

Files are processed in three steps. First, the software detects various properties of the sound wave, including amplitude and frequency, timing, timbre, and spatial positioning. It then applies some statistical analysis that determines how it relates to other files in the database. Finally, it assigns labels to the file so the user can catch a glimpse into the contents of the file, including such categories as male speech, jazz music, explosions, coughs and sneezes, and so on.

As of this writing, the service is in beta test with "some of the world's leading media companies, including music licensing, media creation and production, multimedia search, and digital asset management firms," so you can't tap into it yet. The system, however, has already analyzed nearly 2,000,000 media files ranging from speeches to television sound tracks. In the near future, Imagine "will be working with our launch partners to enable intelligent audio-aware software, apps, and searchable media collections." ▲

CIRCUITS AND DEVICES

DIY SOLAR ENTERS THE MARKET

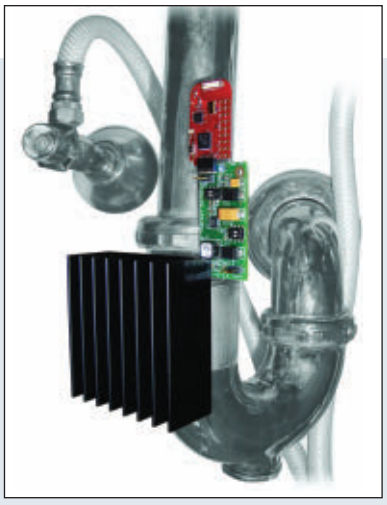
It seems somewhat ironic that while the country was wrapped up in the Solyndra debacle, other solar companies — almost unnoticed — have been busy introducing relatively cheap products. One of Solyndra's blunders was its strategy of avoiding the use of expensive refined silicon, instead basing its products on cylindrical copper indium gallium diselenide (CIGS) modules and thin-film technology. The price of solar-grade silicon has fallen, however, from about $450/kg in 2008 to as low as $55/kg today, making its products about double the cost of Chinese-made panels. Late last year, Westinghouse Solar (**www.westinghousesolar.com**) introduced a range of plug-and-play solar panel kits for do-it-yourselfers, and they're already on the shelf at home stores. It's still recommended that you hire an electrician to connect the system to the electrical box, but you can do the roof-mounting part yourself. The bottom line, of course, is return on investment which has never been favorable, and going completely off the grid is still prohibitively expensive. Westinghouse estimates that the average house would need up to 64 panels to accomplish that. But let's say you just install a few panels to save on the electric bill. Sparing the reader the calculation details, in this neighborhood a six-pack of 235W panels would save about $500 per year under rather ideal circumstances. With the equipment priced at $4,698 from Lowes, we're looking at a rather uninviting 10 year payback period. However, depending on the cost of a kilowatt hour in your part of the country, available credits and rebates, and other factors, it might be worth devoting a section of roof to the concept. A starting point to research whether it works for you is **energy.gov/savings**. ▲

CIRCUITS AND DEVICES CONTINUED

MICRO-SCALE ENERGY HARVESTING

At first glance, it looks like the son of a Rube Goldberg joke, but the drain clamp in the photo is a real life application of the Thermobility™ energy harvesting platform from Nextreme Thermal Solutions (**www.nextreme.com**). Nextreme has marked its turf as "the leader in micro-scale thermal management and power generation solutions," and it specializes in using thin-film thermoelectric technology to convert thermal energy into electric power for various autonomous self-powered applications. When incorporated as a plumbing subsystem, thermal energy from water supply lines is converted to electricity that can be used as a source of power for LED indicators, hands-free faucets, soap dispenser solenoids, and wireless transmitters for data acquisition applications. Harvested power can help reduce the size of batteries or sometimes eliminate them entirely.

The concept is also useful in the HVAC industry, where wireless power generators can be used to drive temperature, humidity, and airflow sensors. They can harvest energy from both hot and cold temperature differences and can even store energy for on-demand power. Maybe it's not as silly as it looks. ▲



■ Nextreme's Thermobility drain clamp harvests energy from plumbing fixtures.

BATTERY OFFERS 25 YEAR OP LIFE

■ The TLM 1550 military/ aerospace-grade battery.

If you're looking for batteries that offer high power, long life, and extended storage (e.g., for military/aerospace systems, defibrillators and other portable medical devices, communications systems, wireless sensors, and other telemetric and remote devices), you might be interested in some products offered by Tadiran (**www.tadiranbat.com**). An example is the new TLM 1550 — a high-voltage/high-rate AA lithium unit. It offers an open circuit voltage of 4.0V and the ability to handle pulses of up to 15A, with 5A maximum continuous load. The TLM is designed to handle extreme environmental conditions, including a self-discharge rate of less than three percent per year at room temperature and a temperature range of -40°C to +85°C. It is also said to be extremely safe in operation and has undergone extensive safety tests, including nail penetration, crush tests, high temperature chambers, and short circuit and charge tests. On top of that, the company claims a 25 year operating life for its products. You probably won't be putting a set in your digital camera soon, though, as they are not exactly cheap. Allied Electronics (**www.alliedelec.com**) lists them for $41.65 each. ▲

INDUSTRY AND THE PROFESSION

PONG TURNS 40

It seems worth noting that the Atari video game called Pong was introduced 40 years ago this year, rapidly becoming the first video game to gain wide popularity and commercial success. It also marked the beginning of the end for electromechanical pinball machines which, although wonderful devices, were expensive, complicated, and difficult to repair. Also notable is the fact that Atari was the first employer of a certain bedraggled, hippie-type, Pong-loving dropout from Reed College. He was taken on as an electronic technician after informing the personnel director that his only choices were to hire him or call the cops to drag him away. That person was Steve Jobs. **NV**

■ Things were simpler in the days of Pong.

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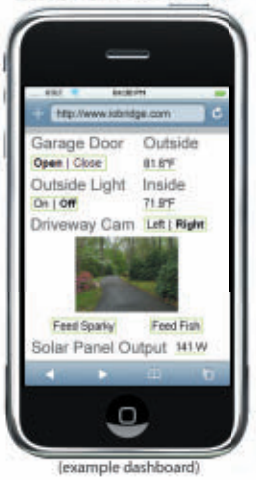

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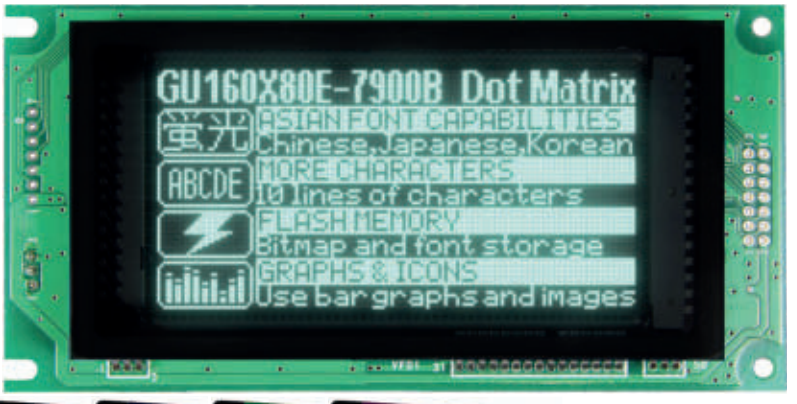

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■ BY RON HACKETT

CONSTRUCTING A TWO-DIGIT SEVEN-SEGMENT LED PROJECT BOARD

Discuss this article in the *Nuts & Volts* forums at http://forum.nutsvolts.com.

A couple of years ago, we explored the basics of interfacing seven-segment LED displays with PICAXE processors (*N&V* PICAXE Primer, 12/09, 2/10, and 4/10). At that time, the PICAXE-20M processor (which includes eight digital outputs) enabled us to drive a single-digit LED display as a simple demonstration of the basics. In order to interface more than one digit with a PICAXE processor, we had two options: multiplexing the display, or using a dedicated LED display driver such as the MAX7219. However, with the recent introduction of the 20M2 processor, we are now able to drive a two-digit LED display without the complication of multiplexing or the expense of a separate LED display driver.

A two-digit LED display may not seem like much, but it can be very useful in a variety of projects, especially in the areas of timing and temperature monitoring and control. I'm currently working on three projects of my own in those areas, and all three of them only require a two-digit display. I've already developed a couple of stripboard circuits for two of my projects, and have started working on a design for the third one.

In the process, it dawned on me that the three different circuits I designed are actually very similar. This realization prompted me to start thinking about a flexible two-digit LED display board that could be easily adapted to a variety of projects. This month's column is the result of all the fun I've been having.

DESIGNING A FLEXIBLE TWO-DIGIT LED DISPLAY BOARD

In the past, I've experimented with driving a multiplexed two-digit LED display with a 20M processor. It can certainly be done, but the 20M is kept so busy with the multiplexing function that it's not able to simultaneously attend to many other tasks. Now that the 20M2 is available, I decided to switch my focus to a non-multiplexed display.

Of course, a non-multiplexed two-digit display requires twice as many output lines, so the vast majority of the 20M2's I/O lines need to be dedicated to the display. Consequently, any additional functions of the board have to be implemented with a minimum number of I/O lines. Keeping that in mind, the following is a list of the additional functions that I decided to include:

Timing: One of my projects is what's referred to as a "shot-timer" for an espresso machine. This is essentially a count down timer which, of course, is a readily available kitchen gadget. However, I wanted to include a couple of custom features in my shot-timer, and it's much more fun to design and build one anyway. Fortunately, the 20M2's built-in *time* variable allowed me to include this feature without any additional hardware requirements at all.

Temperature Measurement and Control: Another one of my projects is a temperature alarm for the freezer in my basement. As you probably know, PICAXE Basic includes two commands (*readtemp* and *readtemp12*) that work in conjunction with the Dallas-Maxim DS18B20 digital temperature sensor, so that's what I'm using for this project.

What you may not know is that the 08M2, 14M2, and 20M2 processors also have an additional temperature measurement capability. Their new *readinternaltemp* command can be used to determine the internal temperature of the processor without any additional hardware. We'll get into the details when we get to the software portion of our project next time.

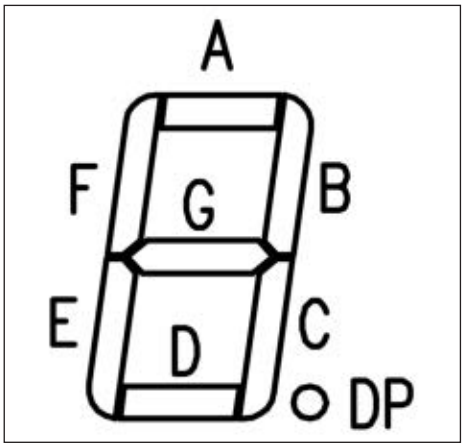
User Input: Of course, we need some form of user input for our board. Setting a timer or an "alarm" temperature is simplified by having a keypad that includes buttons for the

10 digits, as well as a few other control functions (*enter*, *clear*, etc.) Since we'll be using almost all the 20M2's I/O lines to drive the LED display, I only wanted to dedicate one I/O pin to this function. Fortunately, the 20M2's *irin* command now includes a *timeout* parameter that can allow our program to move on to other tasks if the IR input is not received within the time that we specify.

This means that we can use an inexpensive TV remote control for input, without needing to dedicate a second processor as we did before the M2 processors became available. Best of all, we only need one input pin to implement a very convenient input function. On the 20M2, pin C.6 is input only, so that's the pin I chose to implement the "user input" function.

Serial Input from Another Processor: The 20M2's *Serin* pin cannot be used as a general-purpose input pin; its sole function is the reception of serial data. Since we can't use this pin for any other purpose anyway, we'll devote it to the function of receiving serial input from another PICAXE processor. Similarly to our earlier four-digit LED display project, our two-digit board will also be able to function as a stand-alone output device for any PICAXE processor, including the 08M2.

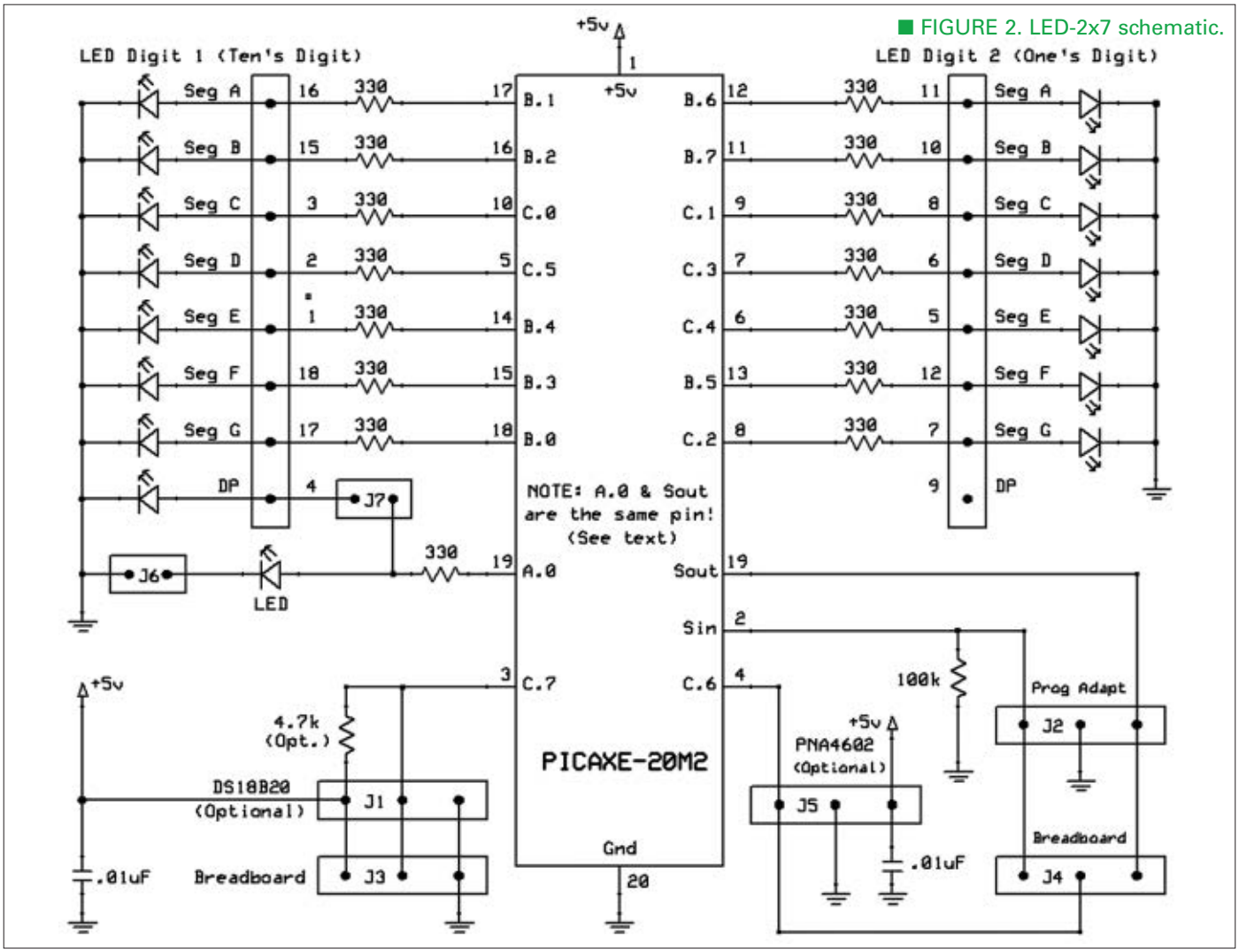
In the following discussion, I'm not going to repeat most of the information that we already have covered in the serial LED project that I mentioned at the beginning of this article. So, you may want to review the earlier articles before proceeding. However, we will need to refer to the standard labels for each of the segments of a seven-segment display, so I've included **Figure 1** for easy reference during our discussion.

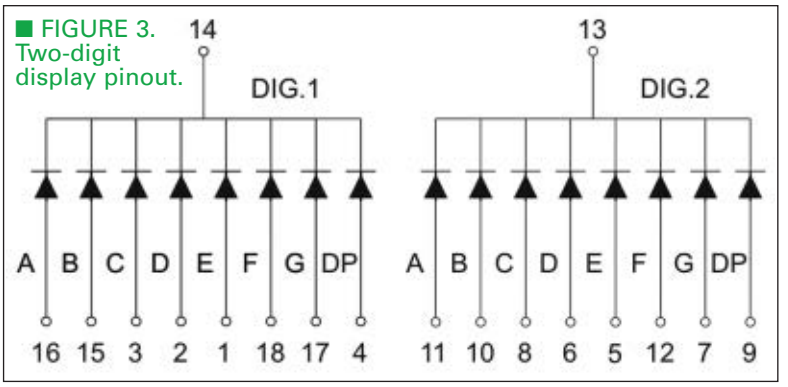


■ FIGURE 1. Standard labels for a seven-segment display.

Figure 2 presents the schematic for my final project design, which I've decided to call the LED-2x7 board. (Clever, huh?) The first thing you may notice about the schematic is that the specific connections that I have made

■ FIGURE 2. LED-2x7 schematic.





■ FIGURE 3. Two-digit display pinout.

between the 20M2 processor and the two-digit LED display seem to make no sense at all! Logically, it would seem to be much more sensible to connect the port B pins to one of the display's digits, and to connect the port C pins to the other digit. However, I did a fair amount of searching on line, and I wasn't able to locate a two-digit LED display with pins that were arranged in any logical fashion. I did find several displays that had the pinout that's shown in **Figure 3**, so I decided to see if I could lay out a stripboard circuit for that pinout in a logical fashion.

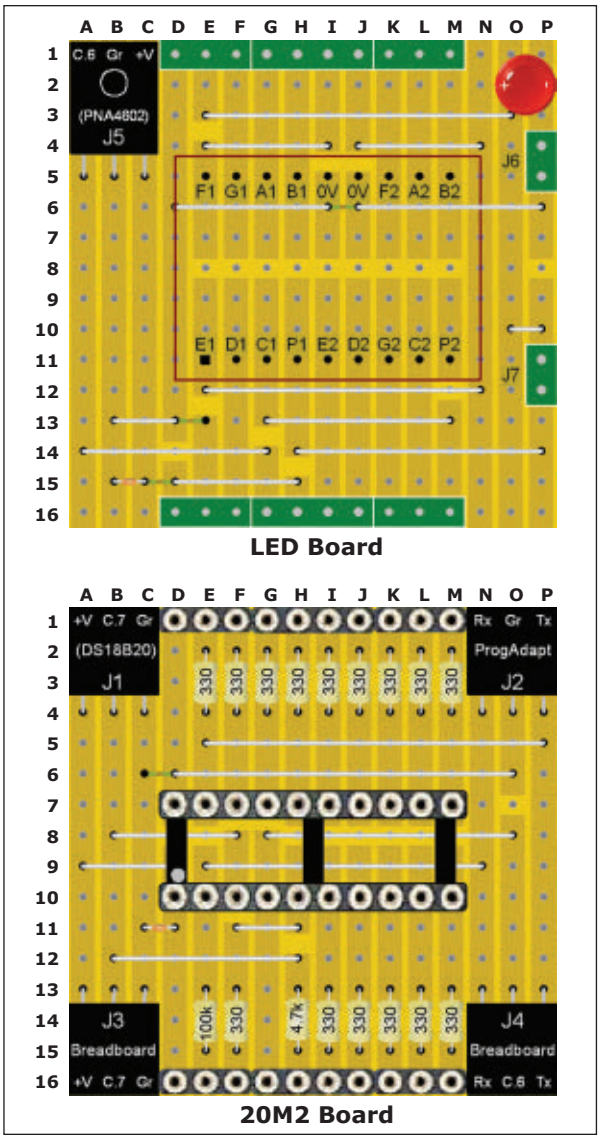
As you might guess, my stripboard kept getting larger and larger, and was a mess! I then realized that I could abandon logic, just make the simplest connections possible, and straighten out the mess in software. I also discovered that I could make the stripboard circuit much smaller and simpler if I used two separate stripboards (one for the 20M2, and one for the LED display) and plugged them together in a "sandwich."

The second weird thing you probably spotted on the schematic is my little note: "A.0 & Sout are the same pin!" Let me explain: When I first started designing the LED-2x7 circuit, I needed one more output than was available on the 20M2 in order to implement all the functions that I wanted to include. Amazingly enough, I remembered that three or four years ago, there was a thread on the PICAXE Forum in which "Hippy" and "Technical" (two members of RevEd's technical support team) explained how it was possible to use the 20M's SerOut pin as a general-purpose output pin by "peeking" and "poking" certain registers (internal memory locations) in the 20M.

I searched the PICAXE Forum archives, found the thread, and tried to take the same approach with the 20M2. After a couple of frustrating hours, I posted a request for help on the forum. As usual, the response was swift and to the point. "Technical" explained that there's an easier way to accomplish the same thing with the 20M2 processor. The PICAXE compiler recognizes "A.0" as an undocumented name for the *Serial Out* pin, and accepts a few undocumented "pseudo" commands, including *high A.0*, *low A.0*, and *Serout A.0*. These are called "pseudo" commands because the compiler simply replaces them with the necessary "peeks" and "pokes" that had eluded me. *High A.0* and *low A.0* were exactly what I needed, and I subsequently discovered that *toggle A.0* also works.

I also discovered that *symbol LED = A.0* does not work (i.e., it produces a syntax error) which a subsequent question to "Technical" confirmed. In any case, I now had the additional (pseudo!) output pin that I needed. Even if you decide not to construct the LED-2x7 board, there may come a time when you need one more output on a 20M2 processor, so you may want to make a note of this information.

As an aside, none of this is necessary on any of the other M2 processors; they all include a "real" name for the *Serial Out* pin, so you can just use that name. For example, on the 08M2, you can write *high C.0* to light an LED on the *Serial Out* pin.



■ FIGURE 4. Top views of the layouts for the two LED-2x7 stripboards.

UNDERSTANDING THE 20M2 STRIPBOARD LAYOUT

Figure 4 shows the top view of the layouts for both stripboards; let's begin with the 20M2 board. Connectors J1 through J4 are three-pin, right-angle female I/O connectors. The pinout of J1 matches the Dallas-Maxim DS18B20 temperature sensor. If a project doesn't include temperature sensing, I/O pin C.7 is available for any other I/O function

that you need. You can directly insert a DS18B20 (flat side down) into J1 for simple temperature sensing experiments. (We will do exactly that in the next installment of the Primer.)

Connector J2 is used for a programming adapter; its pinout matches that of the Prog-03 adapter that I have been using for all my M2 projects lately. If you don't have one, bare printed circuit boards are available on my website, or you could make a stripboard version just for the fun of it. Double-ended male headers can be inserted into J3 and J4 to connect the LED-2x7 board to a breadboard which is how we will conduct our experiments with the LED-2x7. As you can see, connector J3 supplies power from the breadboard to the LED-2x7, and provides access to I/O pin C.7 if you're not using a DS18B20 in a project. Connector J4 provides access to I/O pin C.6 (which is input only) if you're not using a DS18B20 in a project, as well as access to *Rx* (*Serial In*) and *Tx* (*Serial Out*) if you want to program the 20M2 from your breadboard's programming adapter rather than from a separate adapter attached to connector J2.

The 10-pin straight female headers in the middle of the top and bottom rows of the 20M2 stripboard are used for inserting the reverse-mounted straight male headers that you see on the LED board, forming the "sandwich" I mentioned earlier, and connecting the necessary I/O pins to the LED display, the PNA4602 (if used), and the discrete LED on the LED display board. (We'll get into the details shortly.)

The 20M2 board includes a total of 17 resistors. The 100K resistor ties the *SerIn* pin to ground so that the program will run when no programming adapter is attached. (If you trace the connections from the 20M2 board to the corresponding pin on the LED board, you will see that the 100K resistor is, in fact, grounded.) The 4.7K resistor is optional; only include it if you will be using the DS18B20 temperature sensor. (We will discuss the DS18B20 in the next installment of the Primer.) The remaining 15 330Ω resistors are current-limiters for each segment of the LED display: a total of 14 segments for the two digits, plus one for the decimal point for digit 1 (the ten's digit). When I first began designing the LED-2x7 circuits, I wanted to be sure not to exceed the maximum current capabilities of the 20M2, so I made a couple of measurements. If I used a 220Ω resistor, the current draw for one segment was about 13.5 mA; a 330Ω resistor resulted in a current-draw of 9.2 mA. **Figure 5** presents the safe current limits for a 20M processor. (I haven't been able to locate the corresponding data for a 20M2 processor, but I think it's reasonable to assume that it's about the same – famous last words!)

■ FIGURE 5. Current limits for a 20M processor.

	Max. Current
Each Individual I/O Pin	25mA
Total for Each I/O Port	200mA
Total for the Processor	250mA

Let's look at the "worst case" scenario (i.e., the 220Ω resistor): A current of 13.5 mA is well within the safe limit for a single I/O pin. If "8.8" is displayed, all eight port B pins are driven high, so the current-draw on port B is 8 x 13.5 mA = 108 mA; well within the safe limit for a port. Again, if 8.8 is displayed, the 15 outputs will draw 15 x 13.5 mA = 202 mA, which is starting to get close to the safe limit for the entire processor. Considering that current is also drawn by the other ICs — as well as the 20M2 itself — I was starting to get nervous about 220Ω resistors. Fortunately, in the process of making my measurements, I realized that I couldn't discern any visible difference in the brightness of an LED segment regardless of which size resistor I used, so I decided to go with the 330Ω resistors. They produced a total current-draw of about 140 mA when all 15 outputs were driven high, which made me feel much more comfortable!

UNDERSTANDING THE LED DISPLAY STRIPBOARD LAYOUT

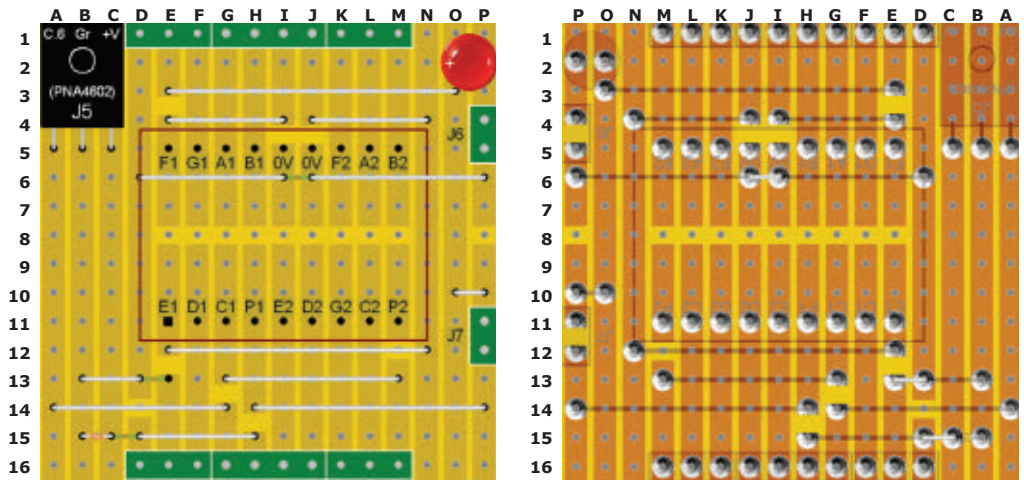
In the LED board layouts in **Figure 4**, I have labeled the LED display using the pinout information presented earlier in **Figure 3**. (Pin 1 of the LED display is in its lower-left corner.) On the layout, decimal point 1 (between the two digits) is labeled "P1" and decimal point 2 (to the right of the display) is labeled "P2" because that's all I could fit. You can use this information in conjunction with the schematic of **Figure 2** to trace the connections from the 20M2 to the LED display. As you can see, the PNA4602 IR receiver is in the upper-left corner of the LED board. Its data pin — which is pulled high by the 4.7K resistor on the 20M2 board — connects to pin C.6 of the 20M2.

The only other aspect of the LED display board that may need clarification at this point is the use of jumpers J6 and J7. None of my current projects require the use of decimal point P1, but you may find a use for it, so I have included an optional connection. Either the discrete LED in the upper right-hand corner or P1 can be connected to pin A.0 (a.k.a., *Sout*) by installing a two-pin shunt on one of the two jumpers (J6 = LED or J7 = P1). You can either trace the wiring or refer to the schematic in **Figure 2** to see how this works.

If you don't include a shunt on either of the two jumpers, both the discrete LED and decimal point P1 are disconnected from pin A.0, making that pin available for other purposes. Finally, as you can also see in **Figure 4**, decimal point 2 (P2) isn't connected to anything. I couldn't think of a need for it which is a good thing because we've already used every I/O pin on the 20M2.

■ FIGURE 6. Parts List for the LED board.

ID	PART
-	Stripboard, 16 traces x 16 holes
-	Jumper wire
J5	PNA4602 IR receiver (Optional)
-	LED, 3 mm or 5 mm, non-resistorized
-	Capacitor, .01 µF
-	LED display, two-digit, seven-segment (LDD5111-11 or equivalent pinout)
-	Two headers, male, 10-pin straight (reverse-mountable)
J6, J7	Two headers, male, two-pin straight (Regular length)
-	Two-pin shunt


A B C D E F G H I J K L M N O P
C.6 Gr +V
(PNA4602)
J5
J6
F1 G1 A1 B1 0V 0V F2 A2 B2
E1 D1 C1 P1 E2 D2 G2 C2 P2
J7
P O N M L K J I H G F E D C B A
Top View
Bottom View (flipped)

■ FIGURE 7. Top and bottom views of the layout for the LED board.

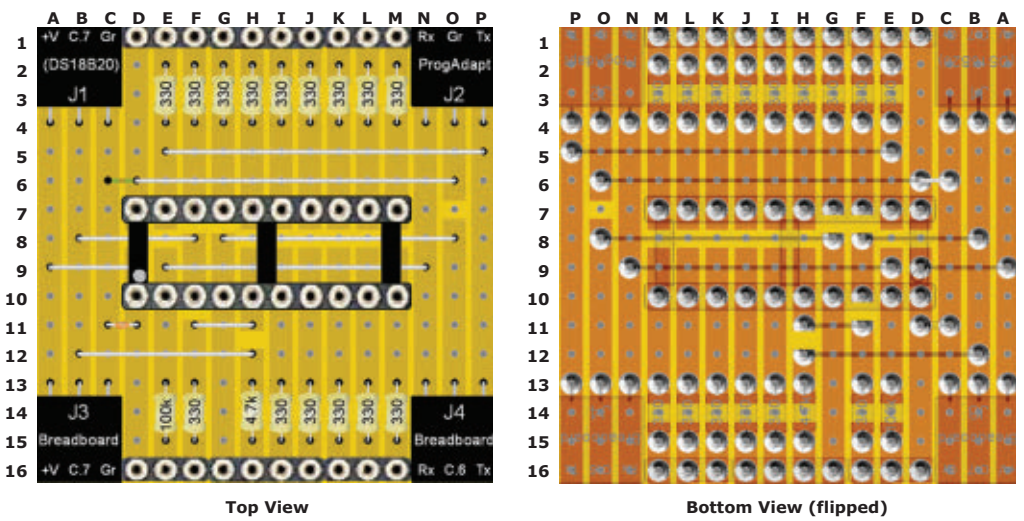
ID	PART
-	Stripboard, 16 traces x 16 holes
-	Jumper wire
J1-J4	Four headers, female, right angle, three-pin
-	IC socket, 20-pin, machined
-	1.5 resistors, 330 Ω, 1/6 W
-	1 resistor, 10K, 1/6 W
-	1 resistor, 4.7K, 1/6 W (Optional)
-	Capacitor, .01 µF

■ FIGURE 8. Parts List for the 20M2 board.

ASSEMBLING THE LED DISPLAY STRIPBOARD CIRCUIT

Okay, we're ready to construct our two boards. We'll do the LED display board first because it will come in handy later when we construct the 20M2 board. A complete **Parts List** is presented in **Figure 6**, and all the parts are available on my website. The top and bottom layouts of the board are shown in **Figure 7**. A full-size pdf file (*LayoutLED.pdf*) is available for downloading at the article link. You may find it easier to refer to the full-size layout as you carry out the following steps. As usual, read through the following list of assembly instructions to be sure you understand the entire procedure before assembling the board.

• Cut and sand a piece of stripboard to the required size (16 traces with 16 holes each).
• Sever the traces on the bottom of the board as indicated in the layout.
• Clean the bottom of the board with a plastic "Scotch-Brite" or similar abrasive pad.
• Cut the 12 required jumper wires to size, and insert them from the top of the board as shown in the layout. Be sure to allow enough length for the three jumper wires that need to be extended on the bottom of the board. **Except for the jumper that extends from location C16 to D16**, solder and snip the leads on the bottom of the board. (You will solder that jumper next!)
• Insert the bypass capacitor at locations B15 and C15. Solder and snip its leads. Also solder the jumper that extends from location C16 to D16.
• Insert the discrete LED at locations O2 and P2, so that its cathode (shorter lead) is inserted at location P2. Solder and snip its leads.
• Optional: If you want to solder the PNA4602 directly to the stripboard, now's the time.
• Insert the two-digit LED display. Be sure to orient it so that pin 1 is at location E11 (i.e., the two decimal points are aligned with row 11). Solder and snip its leads.
• Insert the short ends of the two two-pin male headers from the top of the board at the locations shown for jumpers J6 and J7. Solder the pins on the bottom of the board.
• If you prefer to sand or file any sharp protrusions on the bottom of the stripboard, do so at this point in the assembly.
• Insert the long ends of the two 10-pin reverse-mountable headers from the top of the board and solder the long ends in place on the bottom of the board, using as little solder as possible so that the pins will insert fully into the corresponding female headers on the main stripboard.
• Clean the flux from the



■ FIGURE 9. Top and bottom views of the layout for the 20M2 board.

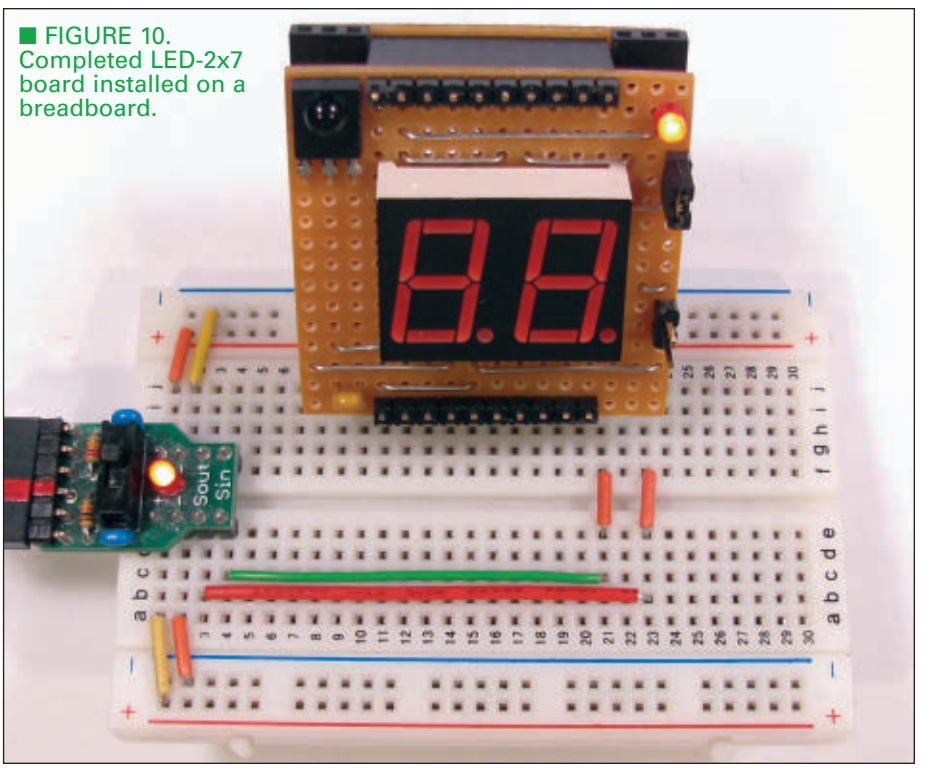
bottom of the board and allow it to dry.
• Inspect the board for accidental solder connections or other problems.

ASSEMBLING THE 20M2 STRIPBOARD CIRCUIT

When you have completed the LED display board, we're ready to move on to the 20M2 board. A complete Parts List is presented in **Figure 8**, and all these parts are available on my website. Of course, you will also need a 20M2 processor which I don't currently stock, but they are available at **www.phanderson.com/picaxe** and **www.sparkfun.com**.

The top and bottom layouts of the board are presented in **Figure 9**. A full-size pdf file (*LayoutLED.pdf*) is also available for downloading at the article link. You may want to refer to this full-size layout as you carry out the following steps, as before. As usual, read through the complete list of assembly instructions that follows to be sure you understand the entire procedure before assembling the board.

• Sever the traces on the bottom of the board as indicated in the layout.
• Clean the bottom of the board with a plastic Scotch-Brite or similar abrasive pad.
• Cut the eight required jumper wires to size, and insert them from the top of the board. Be sure to allow enough length for the one jumper wire that needs to be extended on the bottom of the board, from location D6 to C6. Solder and snip the leads on the bottom of the board.
• Insert the 16 required resistors from the top of the board; solder and snip the leads on the bottom of the board. If you intend to include the optional DS18B20 temperature sensor, also install the 4.7K resistor at this time.
• Insert the four three-pin right-angle female headers as shown in the layout. Before soldering each pair of three-pin headers in place, make sure that a 10-pin straight female header will fit between the two three-pin headers. When you're sure everything fits correctly, you may want to hold the two three-pin headers in place with small spring clamps before soldering them in position. (Do not install the 10-pin headers at this point.)
• Insert the bypass capacitor at locations C11 and D11. Solder and snip its leads.
• Insert the 20-pin machine-pin socket as shown in the layout. Be sure to orient the socket so that pin 1 is at



■ FIGURE 10. Completed LED-2x7 board installed on a breadboard.

BitScope
Digital + Analog
New Model
Pocket Analyzer
Everything in one tiny 2.5" package !
100 MHz Digital Oscilloscope
Dual Channel Digital Storage Oscilloscope with up to 12 bit analog sample resolution and high speed real-time waveform display.
40 MSPS x 8 Channel Logic Analyzer
Captures eight logic/timing signals together with sophisticated cross-triggers for precise multi-channel mixed signal measurements.
Serial Logic and Protocol Analyzer
Capture and analyze SPI, CAN, I2C, UART & logic timing concurrently with analog. Solve complex system control problems with ease.
Real-Time Spectrum Analyzer
Display analog waveforms and their spectra simultaneously in real-time. Baseband or RF signals with variable bandwidth control.
Waveform and Logic Generators
Generate an arbitrary waveform and capture analog & digital signals concurently or create programmable logic and/or protocol patterns.
Multi-Channel Chart Recorder
Record to disk anything BitScope can capture. Allows off-line replay and waveform analysis. Export captured waveforms and logic signals.
Protocol Analyzer
Digital Oscilloscope
Spectrum Analyzer
Compatible with major operating systems including Windows, Linux & Mac OS X, Pocket Analyzer is your ideal test and measurement companion.
bitscope.com/nv

location D10. Solder and snip the leads.
• Insert the two 10-pin straight female headers from the top of the board, and solder the pins in place on the bottom of the board. In order to make sure the two headers are correctly aligned, you can use your completed LED display board as follows:
• Place the LED display board upside-down on a flat surface.
• Insert the two straight female headers onto the pins of the LED board's male headers.
• Position the (upside-down) 20M2 board so that the pins of the two 10-pin female headers of the LED board are inserted in the available holes in rows 1 and 16 of the 20M2 board.
• Solder the 20 pins in place.
• At this point, you may want to sand or file any sharp protrusions on the bottom of the 20M2 stripboard.
• Clean the flux from the bottom of the board and allow it to dry.
• Inspect the board carefully for accidental solder connections or other problems.

TESTING THE STRIPBOARD "SANDWICH"

We're just about out of space this month, but we still have room for a quick test of the complete stripboard sandwich. A simple testing program (*LED27test ABC.bas*) is available with the downloads. We can't discuss how it works this time, but you can still use it to test your project.

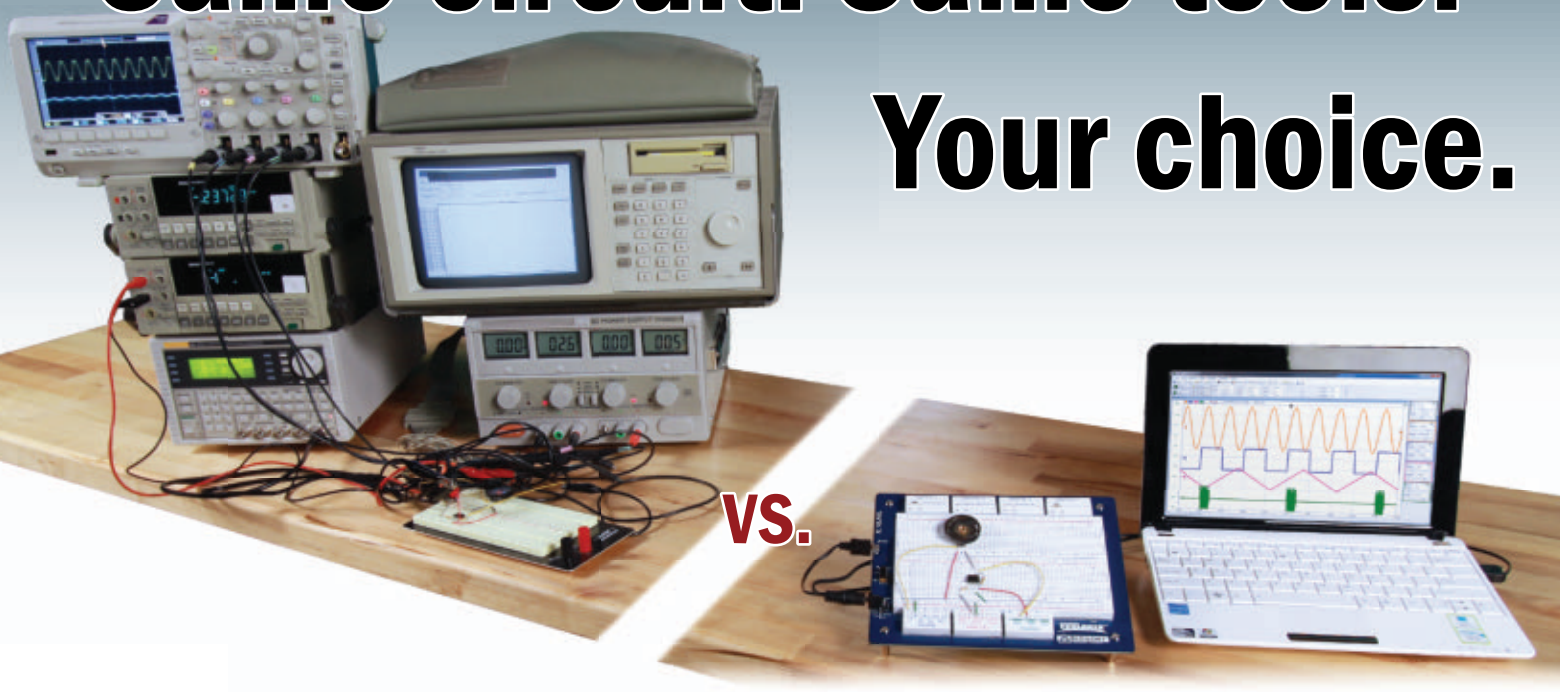
Figure 10 is a photo of my LED-2x7 installed on a breadboard and running the test program. (The power and ground connections are not visible because they are behind the LED-2x7.) As you can see, I'm using the AxMate-FT programming adapter to power and program the board. Of course, you can set up your breadboard circuit using any adapter you have on hand. When you download and run *LED27testABC.bas*, you should see a repetitively changing pattern that has the following characteristics:

• At any given time, only one segment is lit on each digit.
• The two lit segments are always the same (i.e., both are segA, or segB, or ...)
• The segments are lit in the same order as the segment labels in **Figure 1**.
• At the end of each cycle, both digits go blank and the discrete LED (or P1, depending on where you place the two-pin shunt) blinks for one second.
• If the pattern on your display doesn't conform to all these characteristics, you will need to troubleshoot the wiring on both boards.

Next time, we'll get into the software details of untangling the "illogical" I/O connections to the LED display segments. However, there are quite a few hints embedded in our little test program, so you may want to tackle that task on your own. We'll also experiment with IR input to the LED-2x7 board, as well as temperature measurement. Even if you decide not to construct the LED-2x7 board, you will be able to use simple breadboard circuits for our experiments next time.

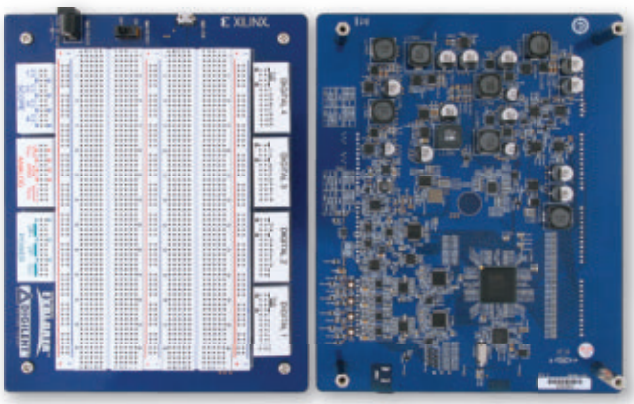
In the meantime, have fun! **NV**

Same circuit. Same tools. Your choice.



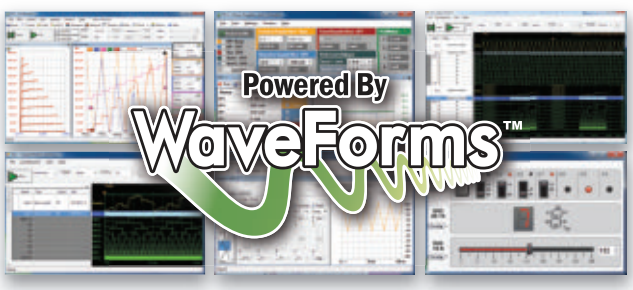
ELECTRONICS EXPLORER™

Integrated Analog/Digital Circuit Design Station



4-channel, 40MSa Oscilloscope
4-channel voltmeter
2 programmable reference voltages
2-channel Arbitrary Waveform Generator
Triple-Output Power Supply (two programmable)
32-Channel Logic Analyzer
32-Channel Pattern Generator
Discrete digital I/O's (buttons, switches, LEDs, etc)

The Digilent Electronics Explorer™ board (EE board) is a complete, all-in-one circuit design station that can turn any PC into a powerful test and measurement system. It combines everything needed to build and test analog and digital circuits into a single, simplified product: a large solderless breadboard, three programmable power supplies, and six test and measurement devices, all accessed using simple jumper wires. The free PC-based Waveforms™ software drives EE Board's high-speed USB2 port to create a powerful, high-bandwidth test and measurement system that responds in near real-time.



The waveform generators support standard and custom waveforms with sweeps, envelopes and modulation. The scope channels offer real-time FFTs, complex math functions, complete cursor and measurement features, and X-Y plots. The digital pattern generator and logic analyzer offer all the standard features and include cross-triggering with the analog instruments. The power supplies include full current and voltage control, and can be actively driven from the waveform generators to create new and interesting stimulus not possible with conventional equipment. These impressive features, together with real-time Bode plots, connection to a PC's sound system, and a host of other features create a truly remarkable piece of equipment.

Now you can quickly and easily build and test analog circuits right on the desktop, and change forever the way you approach analog design.

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Complete System!
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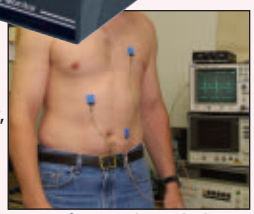
Valentine's Day Goodies!

Electrocardiogram ECG Heart Monitor

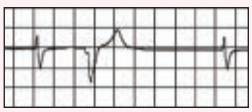
- ✔ **Visible and audible display of your heart rhythm!**
- ✔ **Bright LED "Beat" indicator for easy viewing!**
- ✔ **Re-usable hospital grade sensors included!**
- ✔ **Monitor output for professional scope display**
- ✔ **Simple and safe 9V battery operation**

February is the month for Valentine's Day, and what a great time to think of your heart! Not how many times it's been broken, not how many times it's fallen head over heels in love, but how it actually works... and how it's doing these days! Not only will building an actual ECG be a thrill, but you'll get hands-on knowledge of the relationship between electrical activity and the human body. Each time the human heart beats, the heart muscle causes small electrical changes across your skin. By monitoring and amplifying these changes, the ECG1C detects the heartbeat and allows you to accurately display it, and hear it, giving you a window into the inner workings of the human heart and body!



One of our engineers/guinea pigs, checking his heart!

Use the ECG1C to astound your physician with your knowledge of ECG/EKG systems. Enjoy learning about the inner workings of the heart while, at the same time, covering the stage-by-stage electronic circuit theory used in the kit to monitor it. The three probe wire pick-ups allow for easy application and experimentation without the cumbersome harness normally associated with ECG monitors.



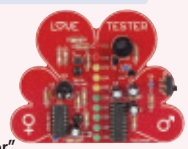
Look what I found!

The documentation with the ECG1C covers everything from the circuit description of the kit to the circuit description of the heart! Multiple "beat" indicators include a bright front panel LED that flashes with the actions of the heart along with an adjustable level audio speaker output that supports both mono and stereo hookups. In addition, a monitor output is provided to connect to any standard oscilloscope to view the traditional style ECG/EKG waveforms just like you see in a real ER or on one of the medical TV shows! See the display to the right? That's was me, when I noticed some skipped beats in my pulse! An immediate cardiac check found I had Trigeminy, or PVCs that occur at intervals of 2 normal beats to one PVC! And I saw it with our ECG1 kit!

The fully adjustable gain control on the front panel allows the user to custom tune the differential signal picked up by the probes giving you a perfect reading and display every time! 10 hospital grade re-usable probe patches are included together with the matching custom case set shown. Additional patches are available in 10-packs. Operates on a standard 9VDC battery (not included) for safe and simple operation. Note, while the ECG1C professionally monitors and displays your heart rhythms and functions, it is intended for hobbyist usage only. If you experience any cardiac symptoms, seek proper medical help immediately!

ECG1C	**Electrocardiogram Heart Monitor Kit With Case & Patches**	**$44.95**
ECG1WT	**Electrocardiogram Heart Monitor, Factory Assembled & Tested**	**$89.95**
ECGP10	**Electrocardiogram Re-Usable Probe Patches, 10-Pack**	**$7.95**

Electronic Love Tester

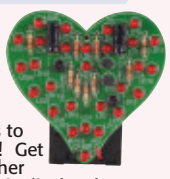


- ✔ **10 LED love scale display!**
- ✔ **Audible love level sound!**
- ✔ **Great party fun!**
- ✔ **Heart shaped PC board!**

This uniquely shaped "Love Tester" is the ultimate gag for any couple! Designed to check your love life, each partner holds one end of the tester PCB at the appropriate male and female touch pads. Then they romantically join hands and watch the results on the love meter! 10 green, yellow, and red LEDs act like a scale, and just like the carnival when it hits the top they flash, indicating you're a red hot couple! There is also an audible alarm that changes with the "love level". Next time the party isn't going anywhere, bring this out, it's a riot! Compatible with all couples! Runs on a standard 9V battery (not included)

MK149	**Electronic Love Tester Kit**	**$16.95**

LED Flashing Heart



- ✔ **28 brilliant red LEDs!**
- ✔ **Unique dual heart design!**
- ✔ **Freestanding mount!**

What a way to display your feelings to that very special person in your life! Get out your soldering iron and dazzle her with this unique dual heart electronic display that you can say you built yourself!

28 brilliant red LEDs are formed into two separate heart designs on the heart shaped PC board creating a great flashing display that's easy to assemble. Built-in battery holder base makes the sweetheart freestanding and perfect for a desk or table. Runs on a standard 9V battery (not included). Measures 2.4" x 2.4" x 1.2".

MK101	**LED Flashing Sweetheart Kit**	**$6.95**

LED Magic Wand

- ✔ **Message floats in air!**
- ✔ **Fun at concerts & events!**
- ✔ **High visibility red LEDs**
- ✔ **Pre-programmed or custom messages**

Use the "Magic Wand" to display your true feelings! Simply shake it back and forth and brilliant messages seem to appear in mid-air! Six high intensity LEDs are microprocessor controlled to display messages and graphics that are pre-programmed into the wand. You can also custom program a message of your choice! From amazing your friends, making a statement at a concert, or simply telling your loved one how you feel, the message wand can't be beat! Runs on two AAA batteries (not included), and features auto power-off.

MK155	**LED Magic Wand Kit**	**$12.95**

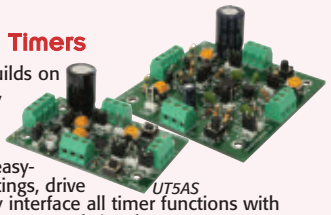
SMT LED Heart Display

- ✔ **Alternating flashing!**
- ✔ **6 super bright SMT LEDs!**
- ✔ **Learn all about SMT!**
- ✔ **Definitely gets her attention!**

This cute little kit gives you a distinctive red display using 6 Surface Mount (SMT) LEDs. The PC board is in the shape of a red heart. The small size makes it perfect to be used as a badge or hanging pendant around your neck. Even better as an illuminated attention-getting heart to accompany a Valentines Day card! Makes a great SMT learning kit to bring you into the world of SMT technology, design, and hands-on soldering and troubleshooting. Don't worry, extra SMT parts are included just in case you lose or damage any! Runs on a small CR2025/32button cell (not included). Measures 1.9" x 1.7" x .3".

MK144	**SMT Flashing Heart Kit**	**$11.95**

Ultimate 555 Timers



UT5AS

This new series builds on the classic UT5 kit, but takes it to a whole new level! You can configure it on the fly with easy-to-use jumper settings, drive relays, and directly interface all timer functions with onboard controls or external signals.

All connections are easily made though terminal blocks. Plus, we've replaced the ceramic capacitor of other timer kits with a Mylar capacitor which keeps your timings stable over a much wider range of voltages! Available in through hole or surface mount versions! Visit www.ramseykits.com for version details.

UT5A	**Through Hole 555 Timer/Osc Kit**	**$24.95**
UT5AS	**SMT 555 Timer/Osc Kit**	**$26.95**

USB PIC Programmer

Finally, a compact USB PIC Programmer with a 20 pin ZIF socket for easy programming of most Microchip PIC Flash devices that does not require low voltage programming. Plus it uses USB therefore no more RS232 compatibility blues!

CK1301	**USB PIC Programmer Kit**	**$34.95**

Doppler Direction Finder

Track down jammers and hidden transmitters with ease! 22.5 degree bearing indicator with adjustable damping, phase inversion, scan and more. Includes 5 piece antenna kit. Runs on 12VDC vehicle or battery power.

DDF1	**Doppler Direction Finder Kit**	**$169.95**

Retro Nixie Tube Clock

Genuine Nixie tubes popular in the 50's brought back in one of the neatest digital clocks around today! Hand made teak & maple base, 12/24 hour format, soft fade-out, auto-dim, and a crystal time base at 20ppm! Available assembled!

HOT SELLER!

IN14TM	**Teak Maple Nixie Clock Kit**	**$329.95**

HV Plasma Generator

Generate 2" sparks to a handheld screwdriver! Light fluorescent tubes without wires! This plasma generator creates up to 25kV at 20kHz from a solid state circuit! Build plasma bulbs from regular bulbs and more! Runs on 16VAC or 5-24VDC.

PG13	**HV Plasma Generator Kit**	**$64.95**

Speedy Speed Radar Gun

Our famous *Speedy* radar gun teaches you doppler effect the fun way! Digital readout displays in MPH, KPH, or FPS. You supply two coffee cans! Runs on 12VDC or our AC125 supply.

SG7	**Speed Radar Gun Kit**	**$69.95**

Broadband RF Preamp

Need to "perk-up" your counter or other equipment to read weak signals? This preamp has low noise and yet provides 25dB gain from 1MHz to well over 1GHz. Output can reach 100mW! Runs on 12 volts AC or DC or the included 110VAC PS. Assmb.

PR2	**Broadband RF Preamp**	**$69.95**

3-In-1 Multifunction Lab

The handiest item for your bench! Includes a RoHS compliant temp controlled soldering station, digital multimeter, and a regulated lab power supply! All in one small unit for your bench! It can't be beat!

LAB1U	**3-In1 Multifunction Solder Lab**	**$134.95**

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Follow us on your favorite network site and look for a lot of super deals posted frequently... exclusively for our followers!

Four-Mode Vehicular Keyless Entry Test Set

THE #1 HOLIDAY KIT!

Ahh!!... the conveniences of today's technology in our modern world! Voice recognition, LED's instead of incandescent bulbs, on-board computers, on-board hard drives, automatic parallel parking, automatic radar cruise control, and of course, wireless remote controls! They make it so simple, just have the "key" (called a key fob) somewhere in your pocket or purse, get near the vehicle, it knows that you are there! Touch the door handle and the vehicle unlocks. Get in and touch the start button and the vehicle starts. You have yet to use a key through the whole process! And don't forget all the wireless controls for your house lights, building access and entertainment systems. They're so great… until they don't work!

Testing your system is easy. To test the complete key fob-to-vehicle and vehicle-to-key fob communications path just stand close to the vehicle with the WCT3 and your key fob in hand. Press the test button and the WCT3 will detect and display the presence of the vehicle's 125kHz/20KHz signal and, if they "handshake", will also detect and display the presence of your key fob's 315MHz return signal. You can independently test key fob only signals (panic, lock, trunk, etc.) by holding the key fob near the WCT3, pressing the test button, and pushing the function button on the key fob. The same functionality testing can be done with IR key fobs. The modulated IR signal is detected and will illuminate the IR test LED on the test set. If you know a few "secrets" you can also see if the tire pressure sensors/transmitters are generating signals or the built-in garage door opener in your rear view mirror is transmitting a signal! But the WCT3's uses go beyond the automotive world. The majority of building wireless access systems also utilize 125 kHz. Just hold the test set near the building access sensor and the WCT3 will detect the 125 kHz signal. That will help you troubleshoot door access locations that are not working. It gets even better... you can use the WCT3 to test virtually any other 315 MHz, 433 MHz, 125kHz, 20kHz and IR wireless control system to verify generation of a signal. The WCT3 test set is housed in a compact 2.25" x 4.6" x 9" case and is powered by a standard 9VDC battery (not included).

WCT3 **Four Mode Keyless Entry Test Set Kit** **$59.95**

Passive Aircraft Monitor

PATENTED!

The hit of the decade! Our patented receiver hears the entire aircraft band without any tuning! Passive design has no LO, therefore can be used on board aircraft! Perfect for airshows, hears the active traffic as it happens! Available kit or factory assembled.

ABM1 **Passive Aircraft Receiver Kit** **$89.95**

Voice Activated Switch

Voice activated (VOX) provides a switched output when it hears a sound. Great for a hands free PTT switch or to turn on a recorder or light! Directly switches relays or low voltage loads up to 100mA. Runs on 6-12 VDC.

VS1 **Voice Switch Kit** **$9.95**

OBDII *CarChip Pro*

The incredible OBDII plug-in monitor that has everyone talking! Once plugged into your vehicle it monitors up to 300 hours of trip data, from speed, braking, acceleration, RPM and a whole lot more. Reads and resets your check engine light, and more!

8226 **CarChip Pro OBDII Monitor-Asmb** **$79.00**

5A PWM Motor Speed Controller

This handy controller uses a pulse width modulated output to control the speed of a motor without sacrificing torque! Handles a continuous current of 5A and includes LED to indicate speed as well as an oversized gold heatsink! Also available factory assembled.

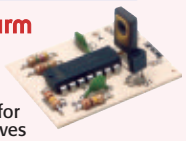
CK1102 **5A PWM Motor Controller Kit** **$14.95**

Digital LED Thermometer

This handy thermometer reads Celsius or Fahrenheit on an eye-catching .56" LED display! Based on the DS18B20 sensor and controlled by a PIC, it has a range of -67°F to 257°F (-55°C to 125°C) with a wired remote range of 325 feet!

CK127 **Digital LED Thermometer Kit** **$29.95**

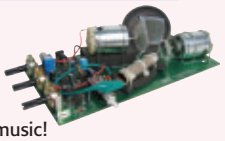
Mad Blaster Warble Alarm



If you need to simply get attention, the "Mad Blaster" is the answer, producing a LOUD ear shattering raucous racket! Super for car and home alarms as well. Drives any speaker. Runs on 9-12VDC.

MB1 **Mad Blaster Warble Alarm Kit** **$9.95**

Laser Light Show



Just like the big concerts, you can impress your friends with your own laser light show! Audio input modulates the laser display to your favorite music! Adjustable pattern & speed. Runs on 6-12VDC.

LLS1 **Laser Light Show Kit** **$49.95**

Water Sensor Alarm

This little $7 kit can really "bail you out"! Simply mount the alarm where you want to detect water level problems (sump pump)! When the water touches the contacts the alarm goes off! Sensor can even be remotely located. Runs on a standard 9V battery.

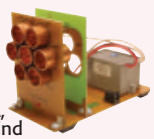
MK108 **Water Sensor Alarm Kit** **$6.95**

USB DMX Interface

Control DMX fixtures with your PC via USB! Controls up to 512 DMX channels each with 256 different levels! Uses standard XLR cables. Multiple fixtures can be simply daisy chained. Includes Light Player software for easy control. Runs on USB or 9V power.

K8062 **USB DMX Interface Controller Kit** **$67.95**

Air Blasting Ion Generator



Generates negative ions along with a hefty blast of fresh air, all without any noise! The steady state DC voltage generates 7.5kV DC negative at 400uA, and that's LOTS of ions! Includes 7 wind tubes for max air! Runs on 12-15VDC.

IG7 **Ion Generator Kit** **$64.95**

Tickle-Stick Shocker

The kit has a pulsing 80 volt tickle output and a mischievous blinking LED. And who can resist a blinking light and an unlabeled switch! Great fun for your desk, "Hey, I told you not to touch!" Runs on 3-6 VDC.

TS4 **Tickle Stick Kit** **$9.95**

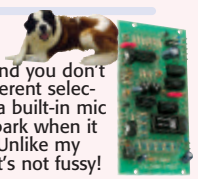
Tri-Field Meter Kit

THE GHOST DETECTOR!

"See" electrical, magnetic, and RF fields as a graphical LED display on the front panel! Use it to detect these fields in your house, find RF sources, you name it. Featured on CBS's Ghost Whisperer to detect the presence of ghosts! Req's 4 AAA batteries.

TFM3C **Tri-Field Meter Kit** **$74.95**

Electronic Watch Dog



A barking dog on a PC board! And you don't have to feed it! Generates 2 different selectable barking dog sounds. Plus a built-in mic senses noise and can be set to bark when it hears it! Adjustable sensitivity! Unlike my Saint, eats 2-8VAC or 9-12VDC, it's not fussy!

K2655 **Electronic Watch Dog Kit** **$39.95**

Electret Condenser Mic

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Q&A

WHAT'S UP:

Join us as we delve into the basics of electronics as applied to every day problems, like:

- ✓ Random Number Generator
- ✓ Battery Tester
- ✓ LED Dimmer

■ WITH RUSSELL KINCAID

In this column, I answer questions about all aspects of electronics, including computer hardware, software, circuits, electronic theory, troubleshooting, and anything else of interest to the hobbyist. Feel free to participate with your questions, comments, or suggestions. **Send all questions and comments to: Q&A@nutsvolts.com**

BLUETOOTH FOR CB RADIO

Q A Honda Goldwing motorcycle has a five-pin plug and cord that interfaces with the helmets. Three pins go to the speakers and two pins from the mic are for the CB radio. Is there a way to convert these signals to Bluetooth so I could eliminate cords and use Bluetooth helmets?

— Gary Harvell

A Yes, all you need is a Bluetooth adapter. Your CB must already have hands-free capability, so a separate receiver and transmitter (as available on eBay) could be used. Or even better, an adapter for two-way radio is available at **www.mobilitysound.com/download/BTD-Mobile%20Bluetooth%20Adapter%20manual.pdf**.

The adapter won't interface with the five-pin connector, so you will have to re-wire that to be compatible.

NONSENSE CIRCUIT

Q I found an old hobby magazine that featured the "Nonsense Box" project that I would like to build for my granddaughter. Can you suggest an equivalent circuit that uses randomly flashing LEDs and a low voltage power supply such as a nine volt battery?

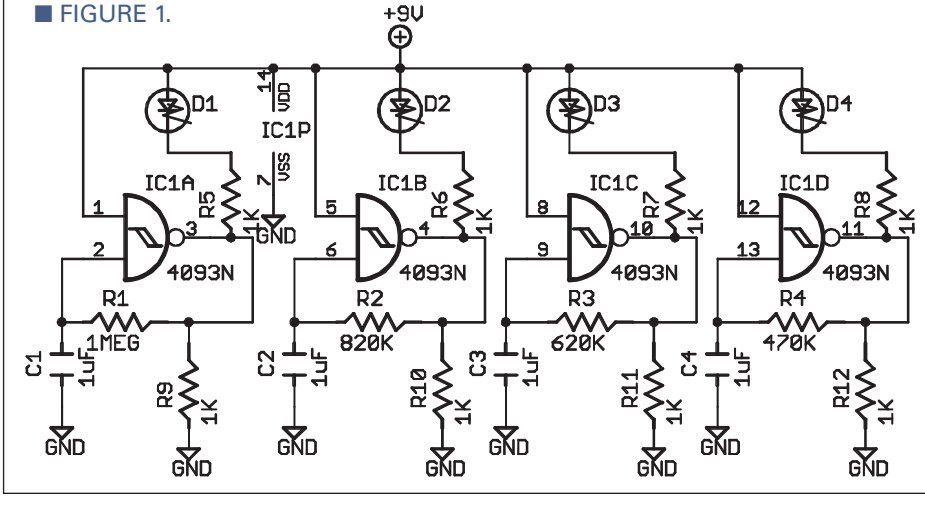
— Jeff Helgoe

A The original circuit consisted of eight neon lamps and a 90 volt battery. The lamp is in series with a capacitor and parallel resistor to complete the circuit. The way it works is the lamp turns on with a voltage drop of 25 volts which charges the capacitor to 65 volts. The resistor is 4.7 meg which is not enough current to keep the lamp lit, so the capacitor discharges through the resistor until the ignition point of the lamp is reached (about 75 volts). Each lamp has the same capacitor value, but the resistors are larger so each one has a different repetition rate.

My circuit (**Figure 1**) does the same thing, except I am using a Schmitt-trigger oscillator to drive the LED. The LED is initially off until the cap charges through the feedback resistor to the trigger point, at which time the output goes low turning the LED on. The cap discharges through the feedback resistor until it reaches the lower trigger point at which time the output goes high, turning the LED off.

I noticed that the off time was shorter than the on time because the output goes high to +9 volts, but the low level is about two volts because of the limited drive capability of the CMOS gate. I added the 1K resistor to ground to even it up. Now, the high level is less than nine volts and the low level is lower than two volts, and the on and off times are nearly equal. I used a 1 µF, 450 volt aluminum electrolytic although a 1 µF, 35 volt tantalum will work (the electrolytic is cheaper; Mouser part number 647-UVZ2W010MPD $0.28).

■ FIGURE 1.



To complete the eight light nonsense circuit, you could duplicate **Figure 1** or use slightly different resistor values such as: 1.1 meg, 910K, 750K, and 510K. Having the resistor values close in value gives the illusion of randomness. If the frequencies are very different, the pattern is easily observed.

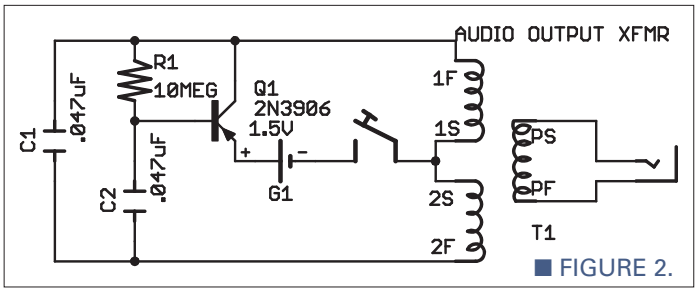
RANDOM NUMBER GENERATOR

Q I need a source of noise to make a random number generator. Articles on the Internet indicate two sources of evenly distributed static are resistor noise and reversing a PN junction A design using the latter involves two 2N3904 transistors with their bases tied together. One is reversed, the other acts as amplification. It worked on a breadboard, but on a PCB I got no more noise out than went in. I think the breadboard injects a little EMI in the bases. Can you suggest a circuit? Preferable 5V or 3.3V in and static suitable for an MCU to read with its ADC.

— Geoff Clark

A Years ago (1970s), I built a noise generator using a reversed biased base-emitter to check the sensitivity of CB radios. If I could hear the noise of the noise generator, the radio had sufficient sensitivity. That told me that the signal level at the source is in the microvolt range. The noise generator had an attenuation of 40 dB, so the noise at the transistor must have been hundreds of microvolts. You will need a little less than 80 dB of gain to get up to volts.

One way to get white noise is to use a sensitive radio receiver connected to the noise generator, and turn up the gain. You will want to band limit the noise because the A/D will average noise that exceeds its bandwidth which will limit the range of numbers. Have you considered a pseudo random number generator? A real time clock can be used to seed the generator and it will generate a different sequence of numbers each time it runs.



■ FIGURE 2.

CODE PRACTICE OSCILLATOR

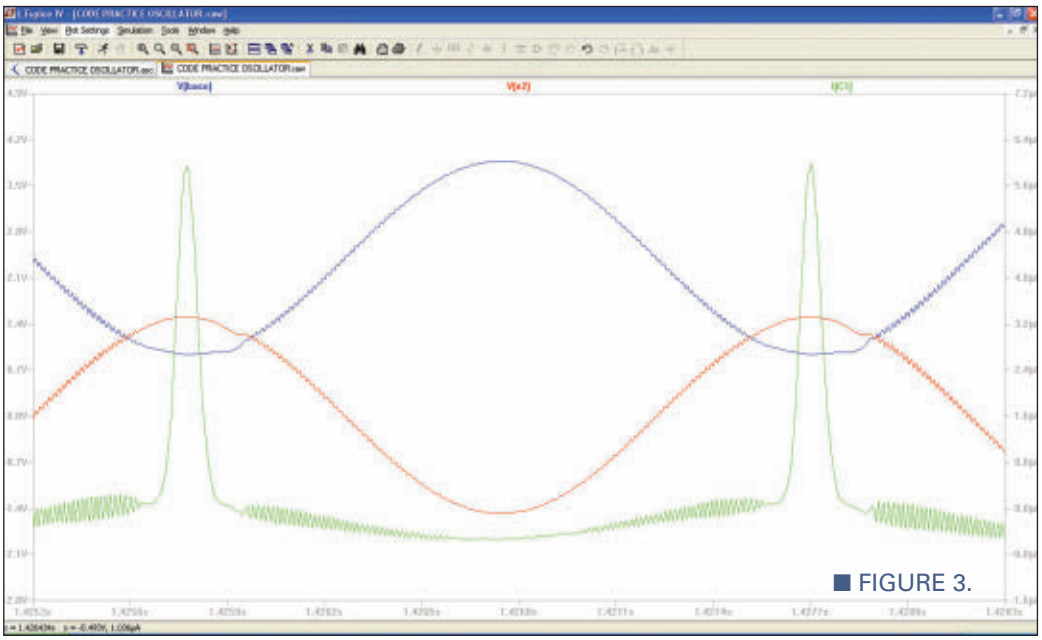
Q Are there any variable capacitors that will work in a code practice oscillator? If so, who has them and what is the cost? The variable capacitor must work with common resistors in an audio oscillator; for example, 47K ohms that will change the pitch of the tone. Hope you can help me.

— Victor Davis

A My first thought when I saw the circuit (**Figure 2**) was: I don't know how this works. I simulated the circuit in LT Spice and, lo and behold, it is a sine wave oscillator.

The circuit operates this way: C2 and the inductance of the transformer primary form a resonant circuit. Any center-tapped transformer should work, but you will have to experiment with values to get an audible frequency. The value of C1 is not critical; I made it equal to C2 for convenience.

Figure 3 illustrates how it works (E2 is Q1 collector voltage): When the base of Q1 is lower than the collector, Q1 is turned on and becomes a short circuit. The resultant surge of current through the transformer energizes the resonant circuit and keeps it going. Note that when the transistor is operated upside down (using the base-collector junction to turn it on), the impedance (Vsat) is much lower than the normal configuration. Also note that the base voltage reaches four volts with a 1.5V supply, so this circuit has voltage boost possibilities.

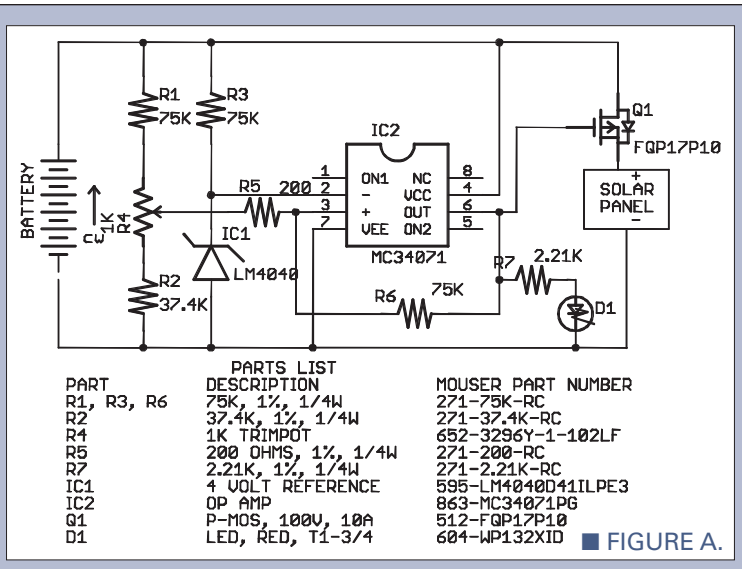

■ FIGURE 3.

MAILBAG

Dear Russell: Re: Convert Logic Circuit to Microcontroller, November '11, page 23. In your column, you indicated that "a microcontroller can only do one thing at a time," but the Parallax PX832A Propeller with eight parallel processors and 16 counters/frequency generators such as is used in the column by Jon Williams could easily handle the type of work Mr. Sellen was looking to do with minimum code.

—Gregg Erickson

Response: Thanks for writing, Gregg. I had no idea this was possible.



PARTS LIST

PART	DESCRIPTION	MOUSER PART NUMBER
R1, R3, R6	75K, 1%, 1/4W	271-75K-RC
R2	37.4K, 1%, 1/4W	271-37.4K-RC
R4	1K TRIMPOT	652-3296Y-1-102LF
R5	200 OHMS, 1%, 1/4W	271-200-RC
R7	2.21K, 1%, 1/4W	271-2.21K-RC
IC1	4 VOLT REFERENCE	595-LM4040D41ILPE3
IC2	OP AMP	863-MC34071PG
Q1	P-MOS, 100V, 10A	512-FQP17P10
D1	LED, RED, T1-3/4	604-WP132XID

■ FIGURE A.

Dear Russell: Re: Figure 4, Solar Collector Schematic, November '11, page 24.
I don't see how the circuit in the diagram shown can function. It would appear that any voltage developed by the solar panel would be blocked by the reverse biased Schottky diode D2. The circuit would not work without the diode either, as the - side of the solar panel would conduct to the - side of the battery continuously, through the MOSFET reverse diode. I know that mechanical contacts are not in vogue anymore, but couldn't Q1 and D2 be easily replaced with an appropriately selected relay?

— Bob Hibbard

*Response: You are right. Oh, my, what was I thinking? I was treating the solar panel as a load instead of a source, and the diode makes no sense. I guess I should publish a corrected circuit with a P type MOSFET on the positive side of the solar panel (see **Figure A**). Thanks for writing.*

COMPARISON OF 555 AND CD4047

Q I'm weaning myself from relay circuitry and am curious about the pros and cons of a clock oscillator based on the 555 circuit and the one shown on the CD4047 datasheet.

I imagine the two different ICs are similarly priced, have much the same power consumption, and are more or less identical in size, so what would influence the oscillator designer towards one or the other of these two ICs? How come the CD4047 has such a bewildering array of input controls — what do they all do?

You've explained that the 555 can be halted by controlling the voltage on the reset pin. Do any of the CD4047's inputs halt and restart oscillation like the 555's reset input?

Relays sure are simpler. And they have nice big solder terminals.

— Stanley Froud

A I have not used the CD4047 but it is an interesting IC. This is how it works (I believe):

When the astable input (pin 5) is high, it is in astable mode and it doesn't matter what state pins 4, 6, and 8 (astable-bar, -trigger, +trigger) are in. It is not good practice to leave them floating; connect them to ground.

When the astable-bar (pin 4) is low, it is in astable mode and it doesn't matter what state pins 5, 6, and 8 are in.

When the astable-bar is high AND astable is low, it is in monostable mode and the +trigger and -trigger can be active. Looking at the logic diagram, I think that if you are using + (rising edge) trigger, the -trigger should be held low; if you are using the -(falling edge) trigger, the +trigger should be held high.

The oscillator out (pin 13) is a pulse — not 50% duty cycle — and the frequency is double the q and not-q outputs, which are 50% duty cycle.

The reset only sets the q output low and the not-q output high, but does not stop the counter. The retrigger input is intended to be used in the monostable mode to make the output time longer; I don't know what it will do in the astable mode, but it may be possible to make one oscillator a slave to the other.

The choice between the 555 and the CD4047 rests on:

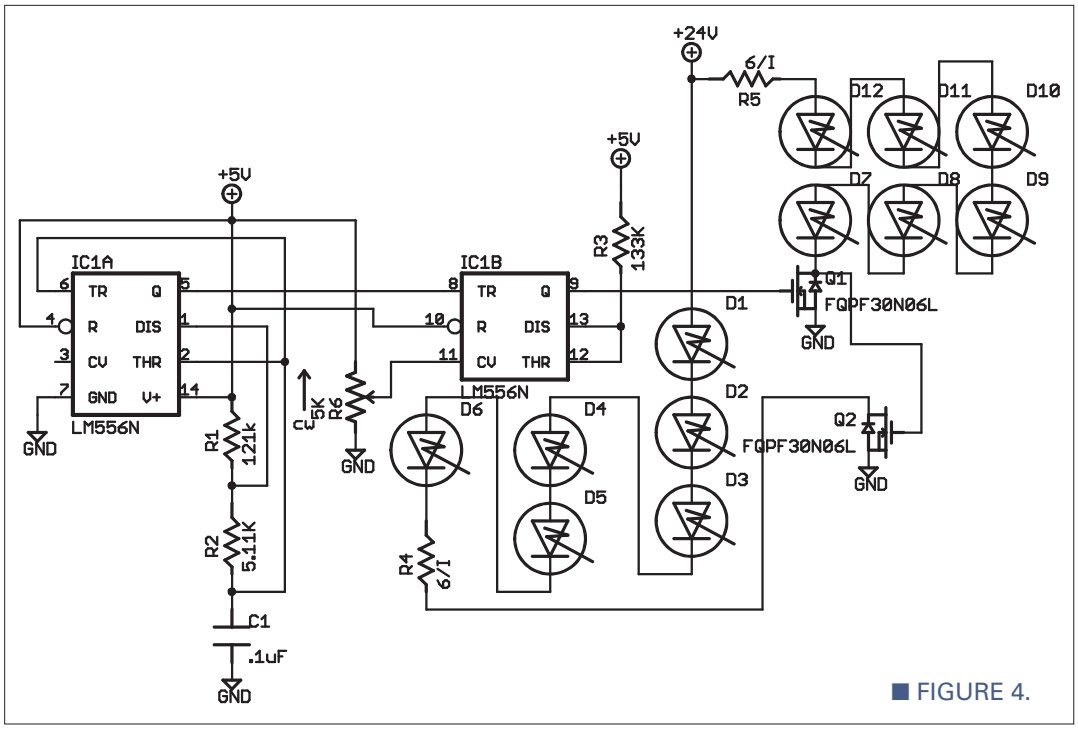
- Do you want 50% duty cycle output? The CD4047 does that but the 555 has limited capability.
- Do you want to pulse width modulate (PWM) the output? The 555 can do that, the CDE4047 cannot.
- Size might be an issue. The 555 is eight-pin; the CD4047 is 14-pin.

LED DIMMER

Q I need a simple circuit to dim an LED light bar while bringing up the intensity of a second LED light bar. In other words, as one gets dimmer the other gets brighter. I think I will need a PWM output and its inverse to do that. Each LED light bar has about six LEDs on it. I could use discrete LEDs also. It needs to be battery powered; I would think about four AA cells for a power supply.

Thanks for your help.

— Tom Bohacek

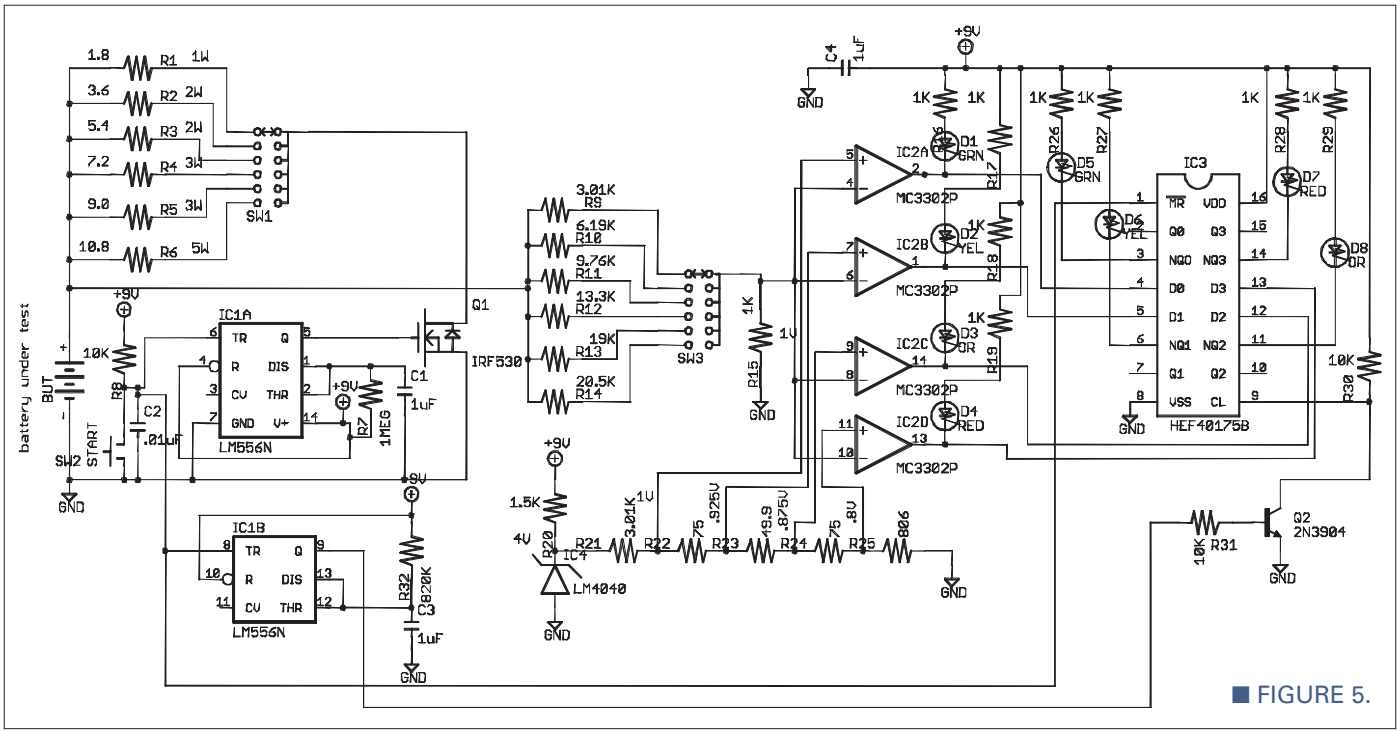


■ FIGURE 4.

A The solution involves a 556 circuit (dual 555). The first 555 sets the frequency by triggering the second 555 (see **Figure 4**). The second 555 does PWM via the control input, pin 11. You don't say what color the LEDs are, but I assume they are white which means each one drops three volts. If the light bar has the LEDs connected in series (most likely), you will need to power it separately with 24 volts. A series resistor of 6/I will limit the current; where I is the rated current of the LED. The LEDs could be run in parallel from five volts — each with its own resistor — but the efficiency will be less.

EUROPEAN POWER TO US POWER

Q I'm moving to a 220 volt 50 Hz country from a 110V/60 Hz world. Ironically, my low power devices (electric razor, laptop, phone charger) are all dual voltage. I do have



■ FIGURE 5.

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RESISTOR VALUES FOR NICAD CELLS ■ FIGURE 6.

CELL	SW1	OHMS	WATTS	SW3	OHMS (1/8W)	DIVIDER	OHMS
AAA	R1	2.4	1/4	R9	301	R21	3.01K
AA	R2	.857	1/4	R10	301	R22	97
C	R3	.2	1/4	R11	301	R23	14
D	R4	.12	1/4	R12	301	R24	74
9V	R5	8.57	1/4	R13	8.4K	R25	815
14.4V	R6	.25	1/4	R14	13.4K		

RESISTOR VALUES FOR ALKALINE CELLS

CELL	SW1	OHMS	WATTS	SW3	OHMS (1/8W)	DIVIDER	OHMS
AAA	R1	.6	1/4	499		R21	3.01K
AA	R2	.3	1/4	499		R22	133
C	R3	.1	1/2	499		R23	67
D	R4	.05	1	499		R24	13.3
9V	R5	1.2	1/4	8.06K		R25	665
6V Lantern	R6	.055	1	4.99K			

a lot of higher power equipment — including power tools — which run on 110V/60 Hz, 2 or 3 KVA. Transformers are expensive, heavy, and don't change the frequency. Any thoughts?

A A motor-generator set is heavy and expensive but a battery charger (or DC power supply) operating on European power could be light; an inverter for US power is normally light. Inverter, 3 kw, 14 lb, $563, Allied part no. 575-0837. Universal input power supply, 12V, 1,500W, $812, Allied part no. 218-0263.

BATTERY TESTER

Q What I think would be a good project is a small battery tester. The tester should pulse the battery at various momentary loads, then give a reading in percent of remaining battery life. It should be able to test AAA, AA, C, D, and the rectangular nine volt batteries — both alkaline and NiCad. It would be good to test button batteries such as those used in hearing aids and calculators. How about a design that we "duffers" can build in the home shop?

A My design is shown in **Figure 5**. You will need different resistor values for the various battery types; the schematic values are for Lithium-Ion cells as used in power tools and portable computers. **Figure 6** is a list of resistor values for alkaline and NiCad batteries.

As soon as the battery to be tested is connected, the LEDs D1-D4 light up to indicate the initial state of charge. For a good test, the battery should be fully charged.

Here is how it works: The one shot, IC1A, turns on Q1 when the start button is pressed which loads the battery under test. The time of IC1A is about one second. After 0.8 seconds, IC1B times out and (through the inverter, Q2) latches the flip-flops in IC3. The start button also resets IC3 to clear any previous test. Switch 3 and associated resistors adjust for the various battery voltages, 3.6, 7.2, 10.8 volts, etc. SW1 and SW3 could be a double-pole six-position like Mouser PN 611-A20615RNZQ.

A fully charged battery will present one volt at the comparators, IC2. A comparison voltage is derived from the voltage reference, IC4. If the battery is fully charged to 4.2 volts per cell, the green LED, D1 will turn on as soon as the battery is connected. If the battery has been charged to 3.65 volts per cell, the yellow LED, D2 will turn on. When IC3 is latched, the state of D5-D8 will indicate the internal resistance of the battery. **NV**

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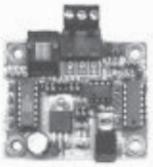

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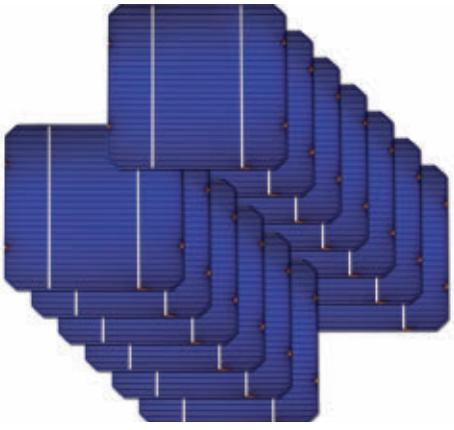
To enable high energy efficiency and quiet operation with low acoustic noise and mechanical vibration, the MTD6505 includes a 180 degree sinusoidal drive. Being a sensorless driver means that the MTD6505 eliminates the need for an external Hall-effect sensor, reducing both cost and board space. Additionally, the driver provides a number of on-chip protection features to preserve the motor's life and avoid harmful operating conditions, including thermal shutdown, over-current limiting, and lock-up protection.

Microchip also announced the MTD6505 Three-Phase BLDC Sensorless Fan Controller Demonstration Board (#ADM00345) which will be available for $59.99. This demo board comes with a three-phase BLDC fan and three MTD6505 plug-in modules. Additionally, a free GUI is available for download that simplifies fan monitoring and control with the onboard PIC microcontroller.

For more information, contact:
Microchip Technology
Web: **www.microchip.com**

2.85 WATT SOLAR CELLS

Parallax is now offering commercial-quality solar cells in its enhanced 34 watt solar panel kit (#33000 Rev B). This results in a maximum output of about 34.2 watts



for the full panel. These solar cells are packaged in a stack between rigid panels, and are shrink-wrapped for safe shipping and storage. Instructions for unwrapping and handling are included. Features include: 2.85 watts output per cell, 0.534 volts output @ 5.34 amps, and a 125 mm form factor.

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- Six-pack (750-00043)
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TSL237 LIGHT TO FREQUENCY CONVERTER

The TSL237 light-to-frequency converter from Parallax combines a silicon photodiode and a current-to-frequency converter on a single monolithic CMOS integrated circuit. The output is a square wave (50% duty cycle) with frequency directly proportional to light intensity. Because it is TTL compatible, the output allows direct interface to a microcontroller or other logic circuitry. The device has been temperature compensated for the ultraviolet-to-visible light range of 320 nm to 700 nm and responds over the light range of 320 nm to 1050 nm. It is priced at $2.99.

Features include:

- Communicates directly with a microcontroller.
- Single-supply operation.
- Compact three-lead clear plastic package.
- High resolution conversion of light intensity to frequency with no external components.

For more information, contact:
Parallax
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NEW PLUG-IN NETWORK MODULE

WIZ820io is a new plug-in network module available from Saelig that offloads Internet tasks to a mini-board that includes WIZnet's popular W5200 IC (TCP/IP hardwired chip + PHY), a mag-jack (RJ45 with transformer), and other peripheral logic. Housed in a very small form factor (23 mm x 25 mm) with two rows of 0.1" spaced pins, WIZ820io can be used as a ready-made component for Internet-enabling a product or board, and is an ideal solution for users who want to develop networked systems rapidly.

WIZ820io contains WIZnet's hardwired Ethernet stack IC W5200, which supports eight independent sockets simultaneously, and features a high speed SPI interface, power-down mode, and Wake-On-LAN function. WIZ820io handles TCP, UDP, IP, ARP, ICMP, IGMP, PPPoE, and MAC protocols.

WIZ820io operates at temperatures from -40 ~ +85 deg C on 3.3V/120 mA, but is 5V tolerant. The module supports half/full duplex operation, auto-negotiation, and auto cross-over detection.

Off-loading the burden of the TCP/IP stack into a second peripheral chip (complete with Ethernet MAC) can minimize product debug issues and reduce time-to-market with TCP/IP stack problems avoided. It also offers the additional benefit of a more stable product, with no possibility of stack overflows.

Continued on page 80

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Channel Surfing With An Arduino

By William Baird

www.nutsvolts.com/index.php?/magazine/article/february2012_Baird

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For several years, I have used my desktop PC as a DVR (digital video recorder). My current setup uses a Hauppauge WinTV-HVR-950Q about the size of a Flash drive that connects to the PC via USB. The other end of the 950Q is a standard cable F connector. The 950Q has its own internal tuner and the software associated with it allows the scheduling of multiple recordings on different channels (useful if you'll be away from home for a few days).

This served me well until my local cable company switched to all digital distribution. This means that a cable box is now required for many TVs — even flat-panel HD models that are just a few years old. The problem is that — as far as my 950Q device is concerned — everything is now on channel 4. All tuning is done on the external cable box. This is similar to the way a TV viewing cable through a VCR would remain fixed on channel 3 or 4, and different programs would be selected through the VCR's remote control.

There are some TV capture cards that include a small IR transmitter that will fix this problem. The capture card will then act like a universal remote, allowing you to change the "real" channel when scheduling a recording, even though the card itself remains tuned to channel 4. Unfortunately, the tiny 950Q does not have this capability.

Recently, when preparing for an overnight trip, I realized that I'd like to record two programs on two different channels. It occurred to me that

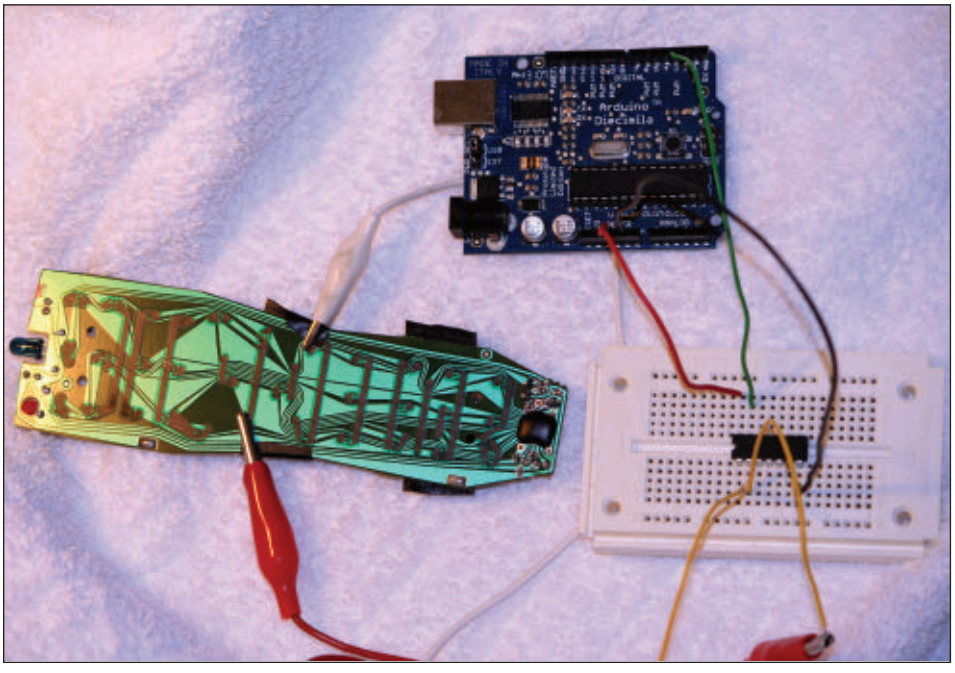
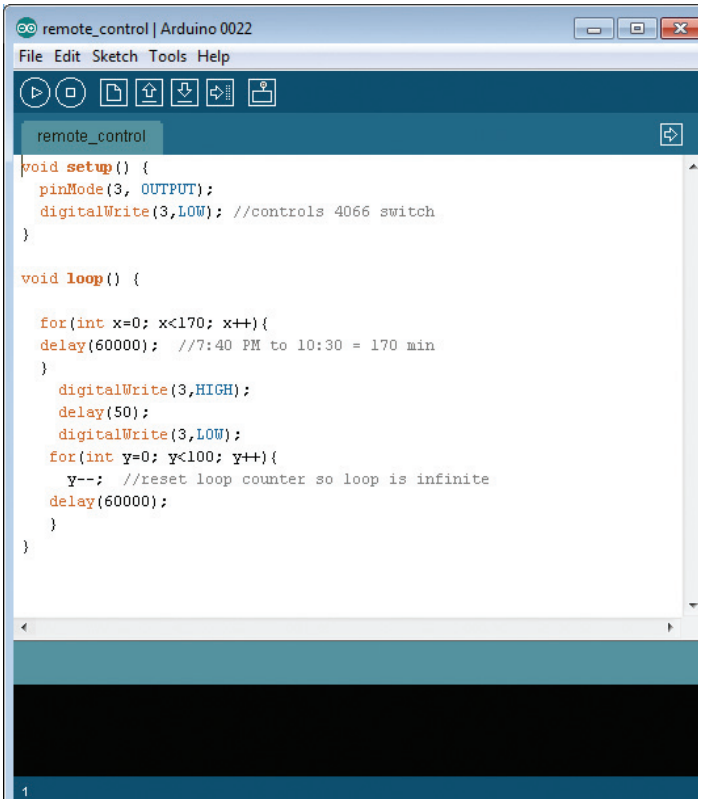


FIGURE 1. Arduino, electronic switch IC, and universal remote control.

FIGURE 2. Arduino program listing to push a single button on the universal remote.



this might be a job for an Arduino. I had the long-term goal of making the Arduino a "smart" universal remote, but I knew I wouldn't have the time to do it that night. My immediate solution was much simpler.

I went out and bought a $5 universal remote control and removed it from its case. After programming it as directed to work my cable box, I experimented with a couple of alligator clip cables to see what connections had to be made to activate a particular button.

In an effort to just solve the current evening's problem, I used the remote to go to the two channels of interest, one after another. At that point, all I needed to do was to have the Arduino control the "last" button. Many remotes have this feature that allows you to switch back and forth between two channels by just hitting the same button repeatedly. I used the CD4066B quad bilateral switch IC (less than a dollar) for this. If you haven't used a switch like this before, it allows you to use a +5V signal to turn a switch on or off. I simply connected the two alligator clips to the two switch ends, and the Arduino to the control pin (**Figure 1**).

The program (**Figure 2**) to time the switch was incredibly easy. I wrote a simple loop that does nothing except "delay(60000);" which gives a 60 second delay and runs from 0 to x. When the loop concludes, the Arduino drives the control pin to +5V, holds it there for a short time (50 ms or so), returns it to the low state, and then goes into an infinite loop doing nothing. The recording program (always recording channel 4, of course) would turn on for two hours at 8 PM, turn off, and then turn on for another hour at 11 PM. Sometime between 10 PM and 11 PM, the Arduino has to change the channel. In the program listing, you can see that I was leaving at 7:40 PM and started the program with a value of 170 for the delay variable x. The Arduino was then supposed to change channels for me at 10:30 PM in preparation for the 11 PM recording.

Although this worked, I knew it was a simple and not particularly powerful solution. If I ever wanted to record shows on three or more different channels, it would not do the job. My long-term goal was to remove the switch and universal remote carcass (which was

FIGURE 3. The Comcast remote control and digital tuner used in this project.

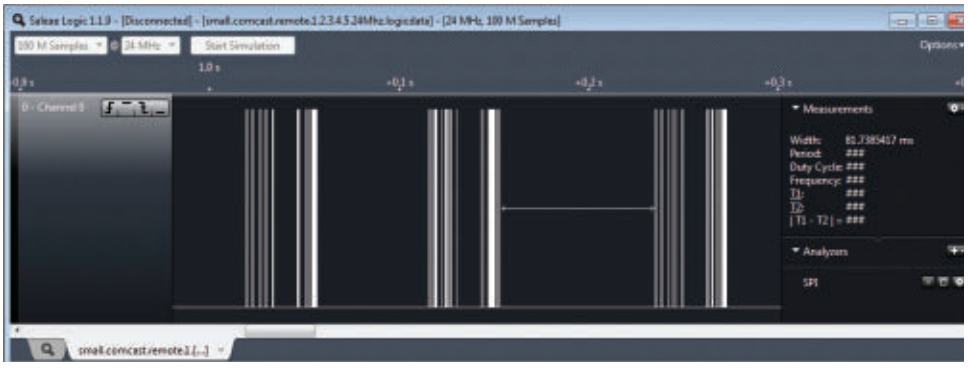


FIGURE 4. The logic output of a "1" from the Comcast remote.

FIGURE 5. The first group of the six sets of lines visible in Figure 4.

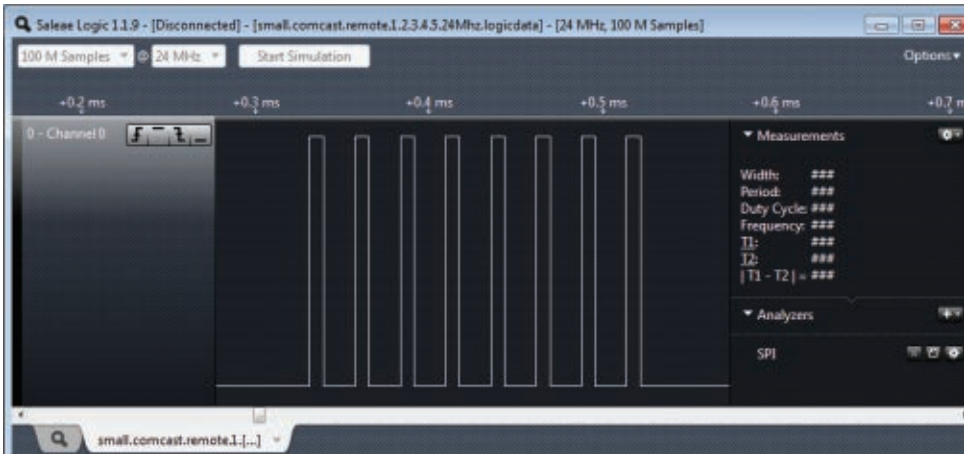


FIGURE 6. Close-up of the first of the nine pulses shown in Figure 5. This is the fundamental pulse sent by the remote every time. Each "fat" line in Figure 5 looks just like this when we examine it closely.

somewhat sensitive to the exact placement of the alligator clip leads) from the picture and just use the Arduino itself as a smart remote control. A quick Google search reveals that there are many websites out there with information about IR remote control protocols and libraries to help program the Arduino to use them. There are even sites that will show you how to use an IR receiver to detect the code with the Arduino, instead of the method described here.

I wanted to do this a different way; I wanted to see if I could just decode what the cable remote (**Figure 3**) was sending and program it into the Arduino on my own, just using the most basic "digitalWrite" HIGH and LOW commands. For this, I decided to use a new toy. The Saleae Logic logic analyzer ($150) was more than enough to meet my needs for this project.

Figure 4 shows the logic analyzer output of what happens when a "one" is pressed on the remote; at this level of zoom, there are three subgroups of lines visible, each divided into two smaller groups.

Zooming in on the first half of the first subgroup of lines, we get **Figure 5**.

We need to go in even closer. Again, zooming in on the first of these nine pulses, we get the picture in **Figure 6**.

Finally, we can see what is happening. Close inspection of the whole sequence of data sent by pushing a "1" shows that *this pattern above is the fundamental word that the IR control understands; delay times between these words provide all of the information the control needs.*

When we look at this, we find that the pulse is high for about 8 µs and then off for about 18 µs. I say "about" because the Saleae device can easily show that these pulses have some significant variation. With just the group of eight pulses shown, we have on times from 7.67 µs to 8.29 µs, and off times from 17.79 µs to 18.46 µs. In other words, this is not a case where nanosecond timing is crucial. Note that the on time plus the off time give a period of 26 µs, or a frequency of about 38 kHz — somewhat standard for IR remotes.

After confirming all pulses were really just these eight on/off transitions separated by some time (making this job far easier), it became clear that the useful data was encoded in the *delay* between pulses. I just had to

gather this information for each key (0-9) on the remote that I wanted to emulate. There are 53 delays to measure for each of the 10 digits which sounds like a great deal of work. All you have to do, though, is bump the mouse over from one delay to the next and record that value (provided by the Saleae program) in a spreadsheet. It can easily be done in less than an hour, and you could probably get the timings for all the other keys on the remote (useful if you want to change volume, mute, etc.) in a similar amount of time.

The spreadsheet (**Figure 7**) made the analysis easy. First, I could see that each button press consisted of three subgroups of pulses, separated by 81.7 µs. While the first subgroup was different from the second for a particular number, the second and third subgroups were identical. By the time I had data for two or three channels, I had figured out that there were only two numbers in each subgroup that changed from channel to channel. Really, instead of gathering 53 * 10 or 530 delays, I would only need six for each digit.

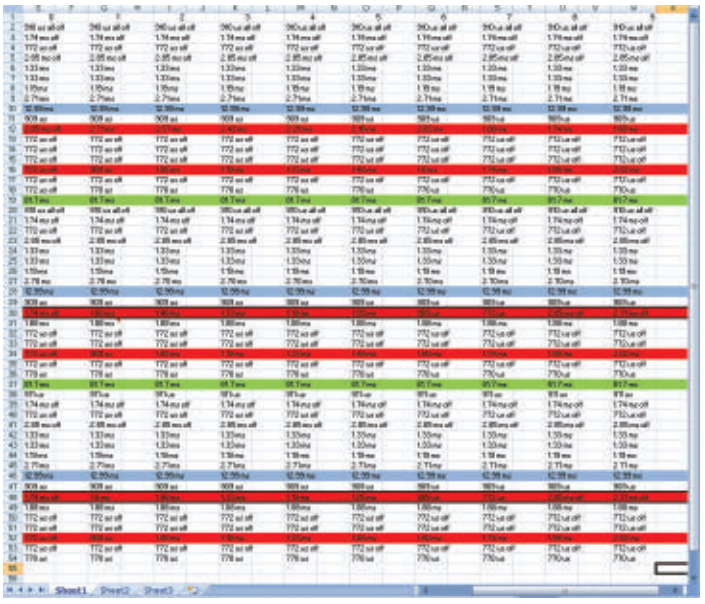


FIGURE 7. Part of the spreadsheet containing inter-pulse delay times for all numbers from 0 through 9.

To make analysis easier, I decided to highlight the rows containing the channel-to-channel differences (red), as well as the medium (blue) and long (green) delays. This general process will work for any IR device you can connect to the logic analyzer. Some may use a different encoding — where the delays are not the significant elements — but the principle is the same: Look at what your remote is saying, and then you can program the Arduino to parrot it back on command.

The *pattern* for channel-to-channel differences was a little harder to spot. If you move across the columns through each red row, you will notice that the delays get either longer or shorter by 140 microseconds from one channel to the next. For example, in row 12 we start out with a delay of 2.85 ms for channel 0, then 2.71 ms for channel 1, 2.57 ms for channel 2, etc. In row 16, our starting delay is 772 µs for channel 0, then 909 µs for channel 1, 1.05 ms for channel 2, etc.

The pattern is reasonably simple, except for the third and fifth set of channel-specific delays (identical to each other; found in rows 30 and 48). In this row, after the numbers have dropped by 140 µs per channel down to 772 µs for channel 7 they jump back up to 2.85 ms and 2.71 ms for channels 8 and 9, respectively. Perhaps delays of 632 µs and 492 µs are too short to be reliable.

Rather than write an algorithm for this, I took the easy way out and just defined a few arrays to hold all of the timing data. The program (**Figure 8**) begins by preparing a pin (I chose number 10 for no particular reason) for output, setting it low, and waiting for a second. This is because the Arduino kept initially setting the state of the pin high after being declared an output pin, and we need to start with the pin in the low state.

The main loop calls the tx (transmit) function once with an argument of 2, waits 0.4 seconds, and calls tx again with an argument of 7. This changes the channel to 27, and the main loop then goes into an infinite wait state. The tx function does all of the real work. It's just reading in a number from the "batch" array to see how long to wait between calls of the "pulse" function, which is what actually sends the eight high/low signals. The batch array is useful because so much of what has to be sent for a 2 is identical to what has to be sent for a 7 or any other number. These constant numbers are given in the batch array in microseconds.

The only exceptions are for channel-specific data and for the long 81 ms delay, since delayMicroseconds won't work with a number greater than 16383. If the tx routine encounters a 0, it automatically waits for 81 ms. The other arrays referencing the three possible unique delays for a channel are channel1, channel2, and channel3. If the tx routine encounters a -1, -2, or -3, it reads the correct channel-specific delay from the corresponding array.

Notice that — at the microsecond level — the speed of the Arduino itself becomes important. With just the stated delays, things weren't working. The pulse function delays to leave the pin high and low are 3 µs and 13 µs rather than 8 µs and 18 µs due to the time spent executing the instructions. The nested if/then/else loop in the tx function takes significantly longer, so the delay times are all reduced by 25 µs. Checking the Arduino's output with the logic analyzer confirmed that these

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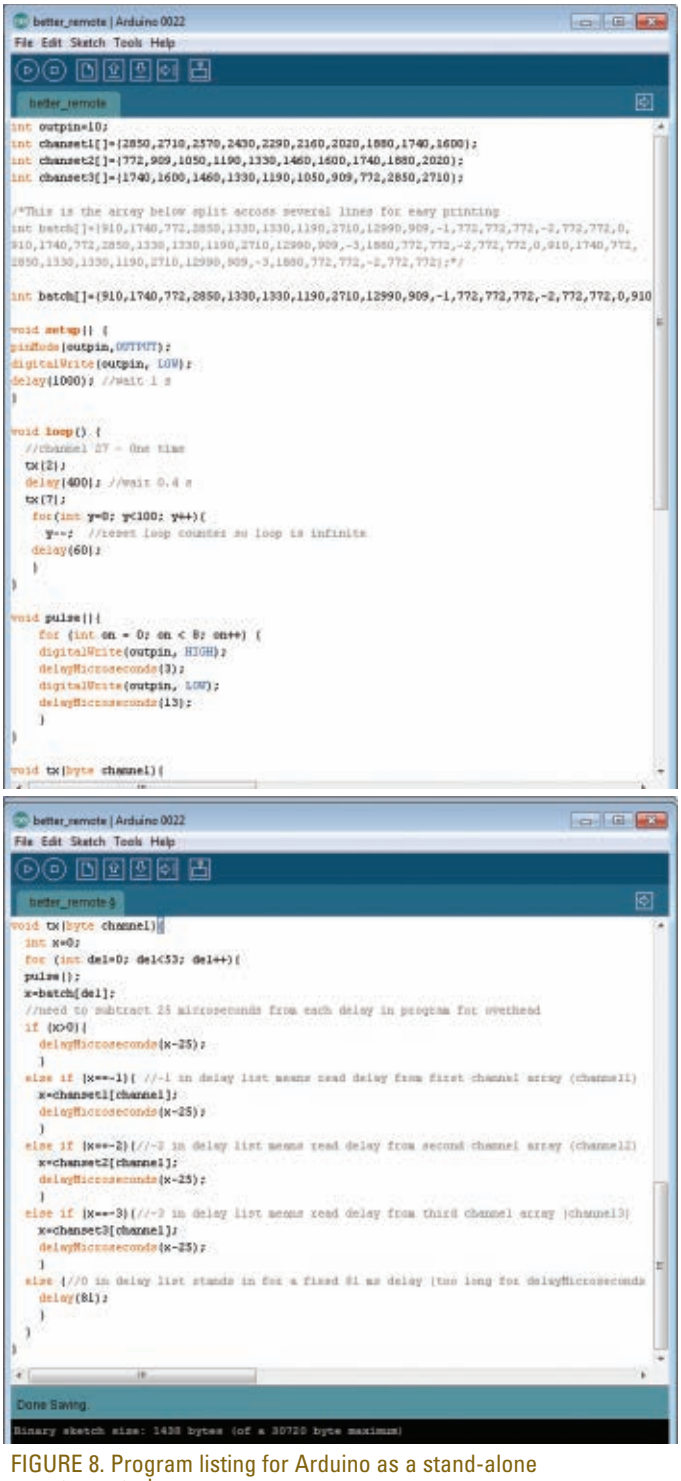

FIGURE 8. Program listing for Arduino as a stand-alone remote control.

changes accurately reproduced what the actual remote control was sending.

The hardware side is the easiest part of the whole process (**Figure 9**). All that is needed is an IR LED (I tried several different ones I had lying around the

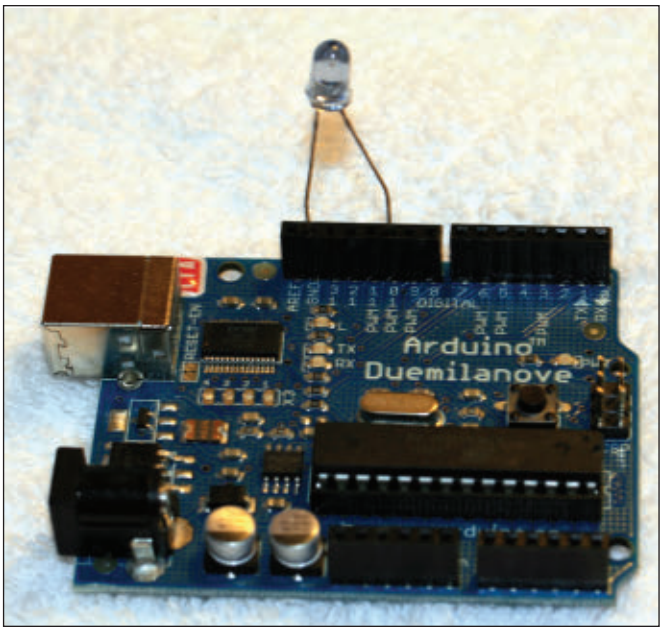

FIGURE 9. The completed Arduino, ready to send instructions to the digital tuner box.

house – clear, smoky, 3 mm, 5 mm — all worked) with its anode in pin 10 and cathode in ground. Just set the delay loop(s) you need before calling tx.

Extensions to this could be interesting. Perhaps the most obvious would be to incorporate something like a DS1307 real time clock so that there would be no need to calculate how many minutes of delay are needed. The day, time, and channel could be programmed directly and the Arduino could just wait for it.

The Arduino itself could be replaced by just the AVR chip (or a suitable PIC or other microcontroller) for a smaller package. A cheap universal remote could provide a ready-made case and means of inputting numbers. Add a small LCD display and you have a truly "smart" remote without a large form factor.

As an intermediate project, notice that while some TVs can be programmed to turn on at a certain time, many can't. An ordinary outlet-based timer and relay won't work, since just plugging in a modern TV won't cause it to turn on. Quick experimentation to find the "power" code from the remote would allow the Arduino to wake you up with your favorite station — even if you went to sleep watching another one. (Much better than a screaming alarm clock!)

If you're going to be away from home and want to periodically turn on the TV to make the place look like someone's home, this is one way to do it. This could be extended to other entertainment devices, as well as cameras (those with IR remote controls), ceiling fans, etc. NV

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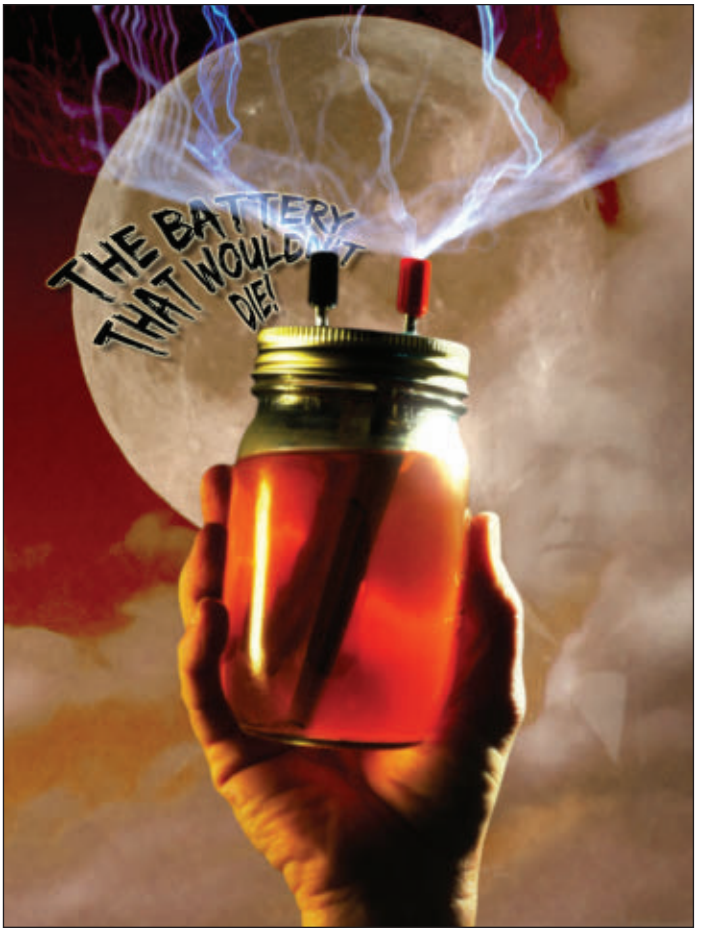
The Edison Cell

By Walter Noon III



With the wild fluctuations in fuel prices over the last few years, world concern over global warming, and simply the idea of creating new and more sustainable technologies, immense interest and progress has developed recently in the world of battery development.

In fact, it seems that every day we hear of a new breakthrough, and another step closer to that long sought elusive goal of a truly workable battery storage system! Perhaps one day soon we'll have a battery that displays no "memory" effect, one that can be completely discharged or overcharged without harm, and require no complex computerized management system. This battery could even prove so durable it will be immune to damage from vibration and not break down chemically over time. In operation, such a battery might even routinely outlast the very vehicle or machine it was designed to operate in! Last, we could complete our wish list by adding in the *impossible*: low materials toxicity, simple construction, and, of course, good energy density.

Does such a battery sound like too much to hope for?

Thomas Edison didn't think so when in 1899 — working with a design pioneered by Waldemar Jungner — he patented a battery with all these characteristics.

It was Edison's hope that electric vehicles — which currently had the lead in popularity — would easily trump internal combustion or steam to be the vehicle of choice of his time, and ours. The Edison cell had a greater energy density than popular lead acid, and recharged in half the time. Astoundingly, it was not harmed by being fully discharged (even if dead shorted for years), and overcharging occasionally was actually good for the cell. It was even recommended as a monthly exercise in the battery's manual!

Edison advertised that the cell had a life of at least four years, but the materials proved to be so stable (due to the low solubility of the reactants in the electrolyte) that some are still producing their full capacity today after more than 50 years! Problems with the Edison cell were few, and included poor performance at low temperatures, a high self discharge rate when unused (20% to 40% per month), and a slower than normal charge and discharge rate (65%). Yet, the practical nature of these cells was undeniable, and perhaps remains so today.

Like many overlooked gems throughout the history of engineering, perhaps these "diamonds in the rough" deserve a second look and some thoughts as to how our present technology could be improved by examining the principles of their operation. Many times historically these cells have been referred to as "the battery that worked too well." Though they were popular and profitable in niche markets for Edison, it has been said that a business model could never be created for the general public by producing a product that does not require replacement. However, these days where "going green" is more than a quaint idea, perhaps Edison's idea has finally found its time.

Constructing an Experimental Edison Cell

Because I know first hand the ingenuity and depth of knowledge of *Nuts & Volts* readers, I'd like to present the

Edison cell to you in two ways. First, I'd like to briefly cover the historical construction of the cell. I think this will spark some ideas and even possible improvements to the cell. Then, I'd like to present the details of my own homemade cell experiments from the last couple years so you can construct one, as well.

Principles of Construction

In many ways, the remarkable Edison cell is functionally the opposite of batteries we use today. Edison used simple iron (anode) and nickel (cathode) screens for the electrodes, submerged in a potassium hydroxide electrolyte. Next, he bucked the popular methodology and rather than a strong acid, used an alkaline electrolyte (potassium hydroxide) for his cell. The basic chemical reaction can be written as:

$$2\ NiOOH + 2\ H_2O + 2\ e^- \leftrightarrow 2\ Ni(OH)_2 + 2\ OH^-$$

$$Fe + 2\ OH^- \leftrightarrow Fe(OH)_2 + 2\ e^-$$

(Discharging is read left to right; charging is from right to left.)

An alkaline electrolyte proved to be not only effective but — unlike acid — the solution were *protective* of the metal electrodes in the battery, giving them their phenomenal lifespan. The alkaline solution was also safer than acid, being about the same toxicity as ordinary bleach. (The raw chemical potassium hydroxide is not so benign, and must be handled with care as we'll see later in an experimental cell.)

Edison claimed that he would not begin actual manufacturing of the cells unless he achieved five times the capacity of the competing (lead acid) cell. At one point, he claimed to have reached 15 times the energy density of lead acid in a series of remarkable experiments.

Edison had found the cell's capacity increased directly with the surface area of the plates. It's hard not to wonder with today's astounding capabilities in miniaturization (and nano machines) what might be possible for plate creation with such robust cells.

Edison Cell: the Electrodes

A cutaway of an actual Edison battery is shown in **Figure 1**. Edison's battery had alternating plates with metal "packets" which contained nickel II hydroxide (Ni (OH)2) for the positive plate, and the iron oxide (Fe3 O4) for the negative plate. In later designs, Edison used perforated tubes for his anode (as seen in this particular cell), instead of packets to hold nickel oxide for the positive plate.

Nickel II hydroxide is a very poor conductor, so in order to make electrical contact with it Edison used 32 layers per centimeter of alternating nickel flake and nickel II hydroxide inside the nickel tubes (as shown in **Figure 2**). So, the positive electrode works by allowing electrolyte in through the perforations in the nickel tube when submerged, and the nickel tubing and nickel flake make contact with the nickel II hydroxide to pass the charges back and forth. Each 10 cm of 6.3 mm (1/4 in) tubing will produce a full 1.25 Ah capacity!

Forming the negative electrode requires only filling tubes (or nickel plated metal packets) with the pure iron oxide (Fe3 O4) under pressure. (This essentially forms little iron oxide briquettes held inside the packets.) Gassing in the cell increases when the negative electrode is charged. So, the negative electrode is typically 30% larger than the positive electrode. This serves to minimize gassing inside

FIGURE 1. Edison cell cut-away.
(Photo courtesy of John DeArmond.)

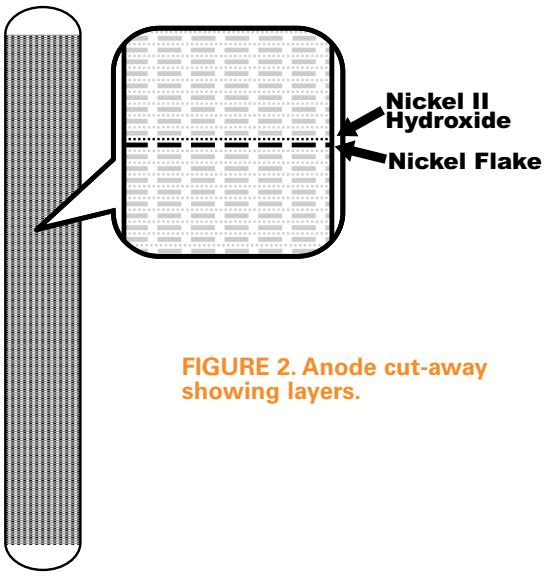


FIGURE 2. Anode cut-away showing layers.

the cell because the cell reaches full charge before the negative electrode reaches capacity.

An Experimental Cell

An experimental cell can be easily constructed on your workbench, and many of the cell's characteristics can be seen and measured first hand. In fact, for a very simple science fair type project a 10 cm square plate of nickel screen and a similar plate of iron will have enough oxides naturally on them after a few charge cycles to light a low power LED for about 12 minutes when charged (**Figure 3**). Though such a cell has a minute capacity, it's still interesting as a proof of concept experiment, and it recharges very rapidly making a nice science fair display.

It's also very interesting that an ultra simple cell of this kind may well have an indefinite lifespan. This might be useful for a millennium project in conjunction with a solar cell for maintaining an ultra low drain memory circuit or some such thing for decades. However, for an interesting and useful project for *Nuts & Volts*, we want to get more capacity in our cell than that!

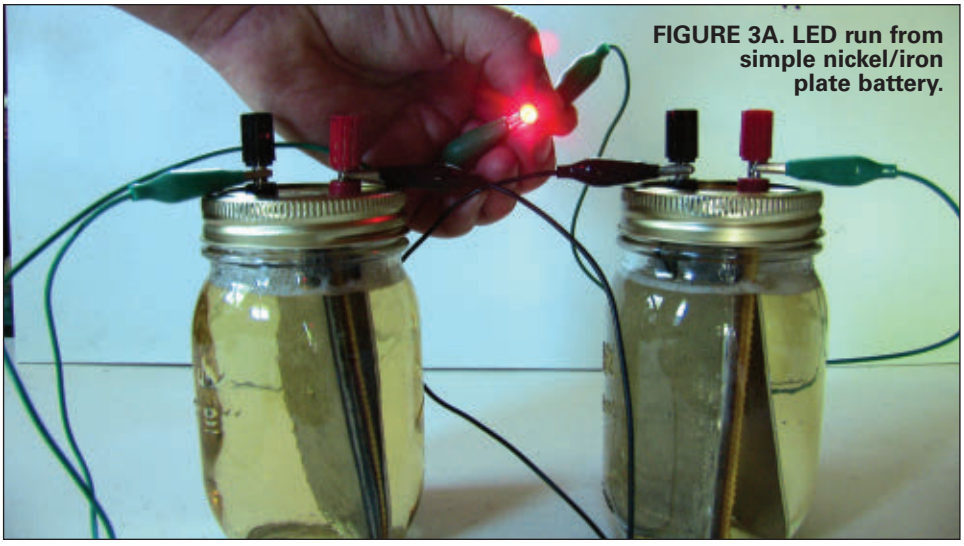


FIGURE 3A. LED run from simple nickel/iron plate battery.

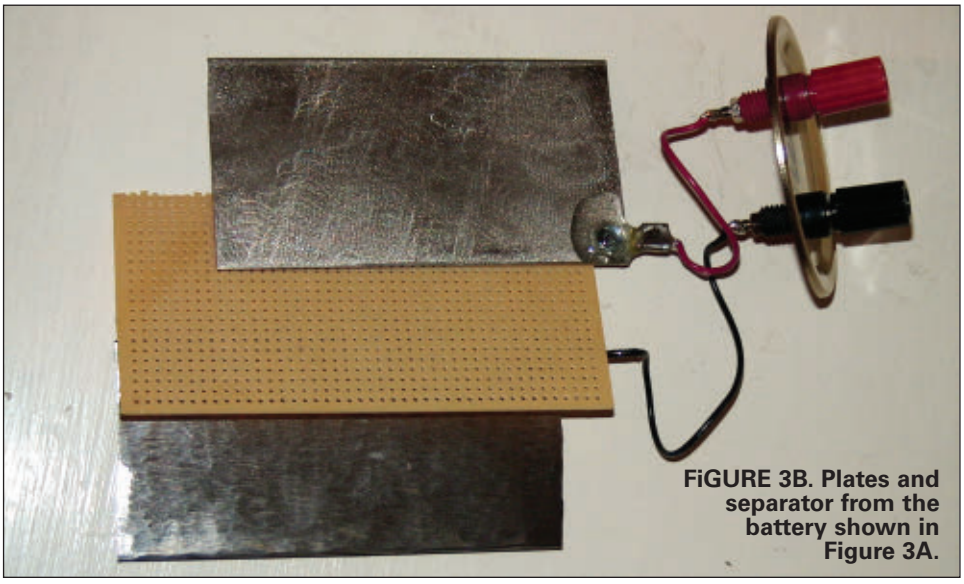


FiGURE 3B. Plates and separator from the battery shown in Figure 3A.

For that, you'll need to procure a small quantity of both nickel II hydroxide and the iron oxide (Fe3 O4), as well as some powdered potassium hydroxide (KOH) for your electrolyte. Chemical supply houses will stock these items.

As an alternative source, I've also found pottery supply houses use oxides of both nickel and iron as colorants in pottery, and are far less expensive than chemical suppliers (see **Sources**).

eBay is an excellent source for potassium hydroxide because it's currently used in making homemade bio diesel and soap.Important note: I have successfully used nickel III oxide *instead* of nickel II hydroxide for my positive electrode with excellent results. It's cheaper, seems to work better, and is much easier to find.

Forming Your Electrodes

A simple idea I had for increasing capacity in our

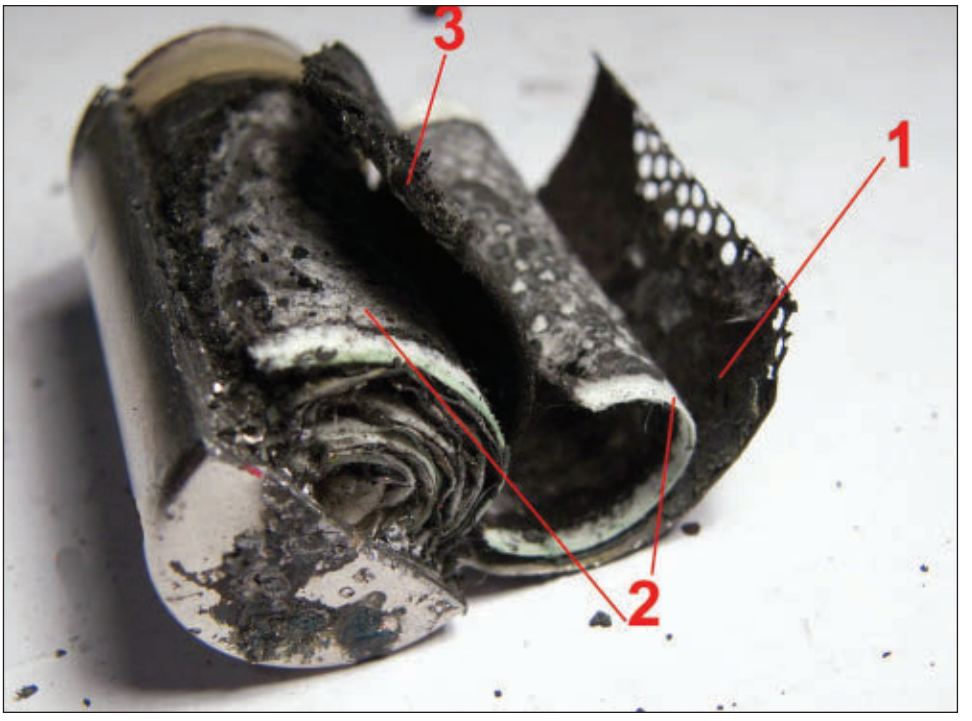


FIGURE 4. Disassembled NiCad. 1. Cathode plate. 2. Separator. 3. Anode plate.

homebrewed cell was to literally use a conductive glue to attach the oxides to the outside of the electrodes. This gives a very high surface area "sandpaper" like finish to the electrodes, which is exactly what we want.

The electrodes themselves need to be nickel, or nickel plated. It's very important to remember in your own designs that virtually any material other than nickel will corrode *rapidly* in this type of cell under the electrical action. If you'd like to do your own nickel plating, **Sources** are included here.

Your plate size can be anywhere from 10 cm square to a little over 50 cm square and still fit easily in a mason jar. It is certainly possible to greatly increase this size with multiple plates or even a standard "jelly roll" battery construction. **Figure 4** shows this jelly roll construction of a NiCad battery.

Of course, your plates must not touch each other in the cell, so you may need to use a permeable non-conductive separator. This is actually a big topic, but for an experimental cell, it's possible to use layers of fiberglass screen (available at any hardware store).

For my own simple cells (pictured), I soldered some solid copper wire to a fine copper screen (I think copper foil or plate would work, as well). I coated the solder connection with epoxy, and then nickel plated the screen.

Next, I simply coated the screen with a very thin layer of conductive epoxy (it goes a VERY long way if spread thin). (Conductive epoxy can be found in both nickel bearing and silver bearing.)

Last, I sprinkled and pressed powdered nickel oxide into the wet glue for my positive plate, and iron oxide for my negative plate. The results can be seen in **Figure 5**.

Though I'm not certain what the actual longevity of using epoxy to hold oxides to the plates will be, my test cells are now more than a year old and have been charged daily from solar cells without problems. So, mark this method as seems to work but, of course, is still experimental.

I'm certain that other methods of making contact with the oxides in solution will occur to you, so feel free to experiment!

Mixing Your Electrolyte

Begin by mixing a 20% solution (by weight) of potassium hydroxide and *distilled* water in a pyrex beaker. Keep in mind while doing so that potassium hydroxide should be added *slowly* to the water; never the other way around. Potassium hydroxide will react exothermically and some heat will be generated.

Gloves and goggles should always be used, and

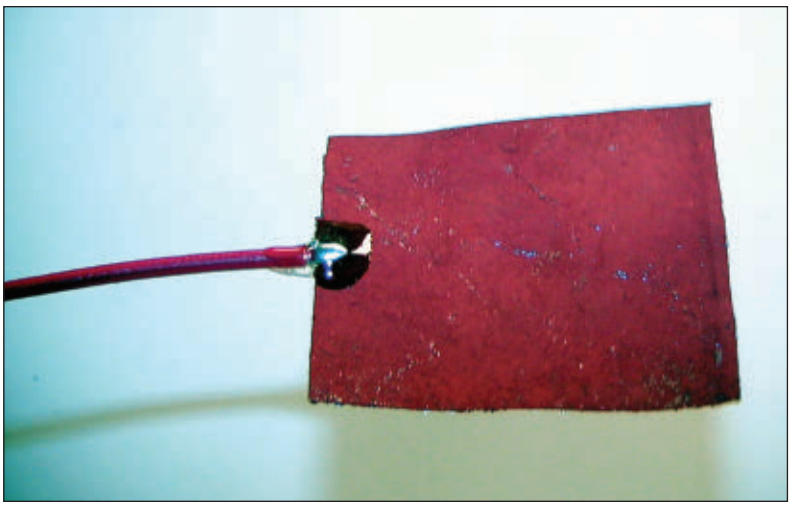


FIGURE 5. Homemade plate.

FIGURE 6A. Plates mounted in cells.

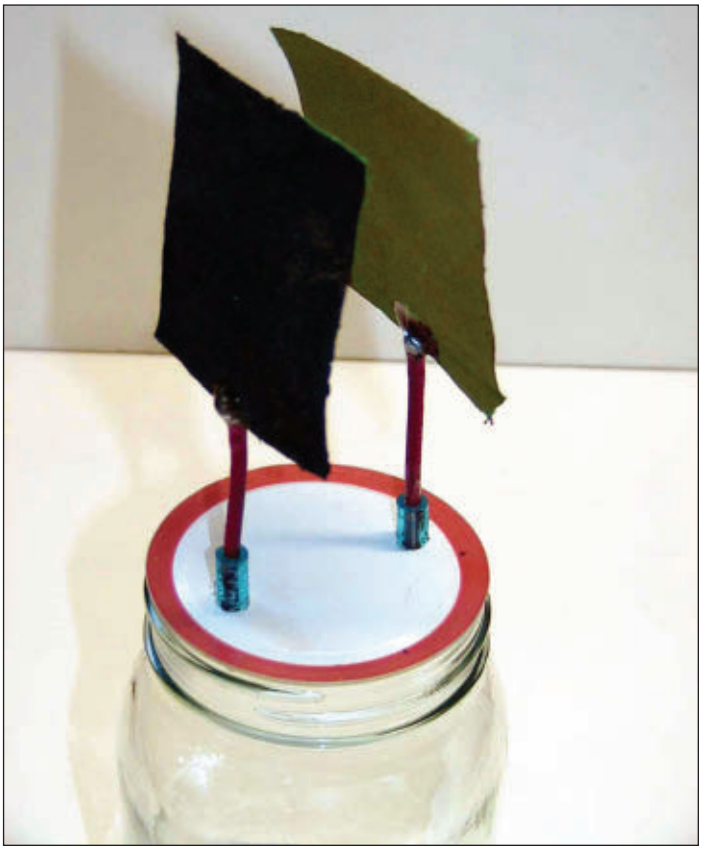


FIGURE 6B. Plates outside the cell.

proper ventilation kept in mind. Raw potassium hydroxide powder should be handled carefully. It is caustic enough that *it will cause burns if left in contact with your skin over a period of time*. So, take reasonable care.

Fill the mason jar with the potassium hydroxide solution, keeping the level well below the lid; screw the lid on the jar. An assembled cell with both plates is shown in **Figure 6A**, and a shot of the separate plates in **Figure 6B**. (Remember, you can use larger plates than shown for greater capacity.)

Your cell is now ready for charging!

Note: Commercial cells also use lithium hydroxide (15g/l) in the electrolyte which further protects the cell at higher voltage charging.

Charging

Each of your Edison cells will produce 1.2 volts. Edison himself recommended charging these cells initially at 1.7 volts (for 48 hours) as a forming charge, and that daily chargings should be made at 1.45 volts to reduce gassing. Your cell will improve each time you charge/discharge it. He also recommended only discharging your cell to .9 volts while your plates are still forming.

Your cells will take on a charge very slowly, especially at first. Limiting current to 50 milliamps or less is recommended for the first charge, though Edison said larger currents are fine as long as the electrolyte does not "froth" or exceed 115 degrees. Some gassing at the terminals is normal and harmless. If liquid levels begin to get low in the cell, add distilled water only.

After your cell has checked out and is working exactly as you'd like, you can add 2 mm of mineral oil to the top of the cell. This will form a barrier against carbon dioxide, which can harm the cell over long periods of time.

A Unique Project

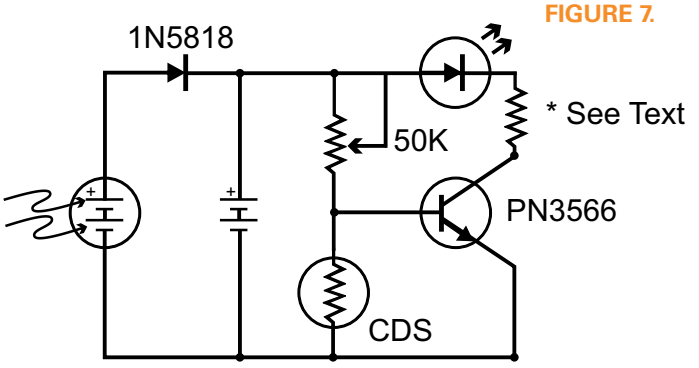
In trying to think of a fun and useful way to test such a long lived cell, I struck upon the idea of a "20 year garden light" as a project.

It occurred to me that using these homemade cells in place of the usual NiCad or NiMH batteries in a solar powered garden light (which usually only last a couple years at best), I might wind up with a light whose battery outlived its solar panel and other components. A quick test showed that two of the described hobby cells could

power a *low power* LED overnight, so I set up a simple solar night light that has been working for about a year now.

Figure 7 shows a typical "on after dark" circuit. The resistor at the transistor's collector should be calculated based on your LEDs operating volatage and the number of cells you choose to use in the circuit. The 50K pot will determine the circuit's sensitivity to sunlight.

FIGURE 7.



Final Thoughts

Though the homebrewed cell outlined here has a very limited capacity, I hope you'll find its fundamentals as truly fascinating as I have.

I believe all the principles necessary are here for creating larger cells and following in Edison's considerable footsteps in other designs.

Surprisingly, my first introduction to Edison cells was at a local energy fair more than 15 years ago. A professor from a junior college exhibited a Volkswagon converted to run on a large set of antique Edison cells. The cells in his car — many more than 50 years old — had been operating his Volkswagen with off-the-shelf motor and other components throughout the school year. He claimed a range of nearly 100 miles, and a top speed of 60 MPH ... besting many of the new breed of electric cars today!

New batteries may well soon eclipse what has been done in the past, but sometimes older technology can surprise you! **NV**

SOURCES

For a simple nickel plating video/method:
www.noonco.com/nickel/

A good source for pottery oxides/pigments:
www.uspigment.com/

For industrial quality conductive epoxy:
www.ellsworth.com/

For electrolyte chemicals
(and often oxides as well)
www.ebay.com/

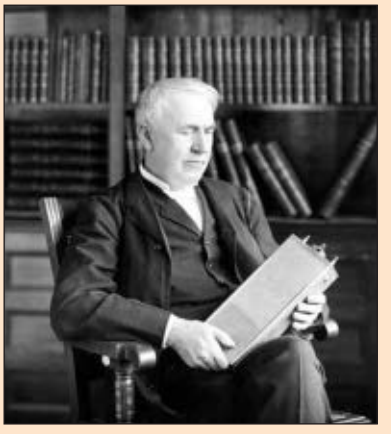
For top (laboratory) quality chemicals, I'd recommend suppliers like United Nuclear, Spectrum, and always a google search!

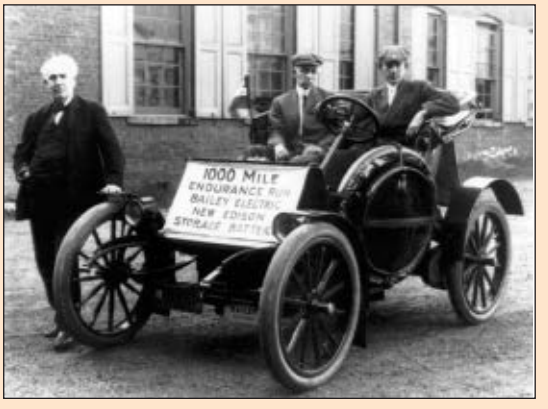
I'll make additional information (including a video showing the construction of the simple cell and nickel plating) available to *Nuts & Volts* readers at **www.noonco.com/edison**.

I'd like to thank Ellsworth Adhesives for donating the conductive epoxy, and Dr. Vijayamohanan K. Pillai for his encouragement and advice in sorting out the fact and fiction on these remarkable cells.

Every Detail of Construction of the
EDISON ALKALINE STORAGE BATTERY
is an argument in favor of its universal adoption in
Wireless Installations
Steel Container—Unbreakable.
Potash Electrolyte—Preserves metal and produces no obnoxious or injurious fumes.
Steel Grids and Pockets—Unaffected by extreme vibration. Reliable even after a collision.
Connectors—Copper wire in lugs over tapered poles. Perfect electrical connection without "lead burning."
The Edison Storage Battery may, without harm, be short circuited, charged in the reverse direction, left standing idle indefinitely either charged or discharged, charged at rates several times normal and at any time regardless of the state of charge.
The Edison Storage Battery is guaranteed to be capable of developing 100 per cent capacity at the end of four years.
EDISON STORAGE BATTERY CO.
213 Lakeside Avenue Orange, N. J.

An old Edison advertisement.


Edison with his battery.



Edison and the Bailey electric car (1,000 mile endurance test).

CREATING A VIRTUAL SERIAL PORT WITH THE 32-BIT MICRO EXPERIMENTER

BY THOMAS KIBALO

Discuss this article in the Nuts & Volts forums at http://forum.nutsvolts.com.

The Universal Serial Bus (USB) has made it very simple for end-users to attach peripheral devices to a PC, all but eliminating the myriad of different interconnects that used to be necessary. One such traditional legacy interconnect that is becoming increasingly rare is the RS-232 serial COM port. In fact, many modern laptop computers no longer have one.

In the Oct '11 Experimenter article, we stated that legacy communications (i.e., serial port with a PC) are still widely used with microcontrollers. This presents an issue to those applications still needing a serial port on a PC. No worries! With the 32-bit Micro Experimenter, Microchip's USB Firmware stack, and its USB device interface we can provide all the required functionality for a virtual serial port without any additional hardware. This USB serial port is designated as a CDC (Communication Device Class).

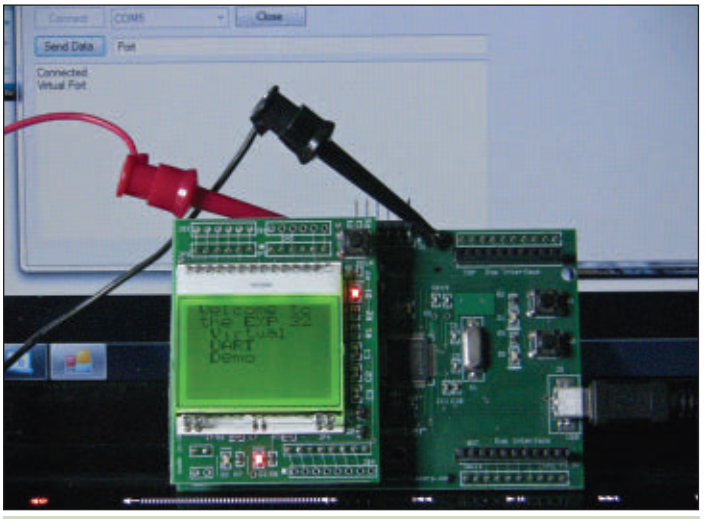


FIGURE 1. Experimenter as a virtual port.

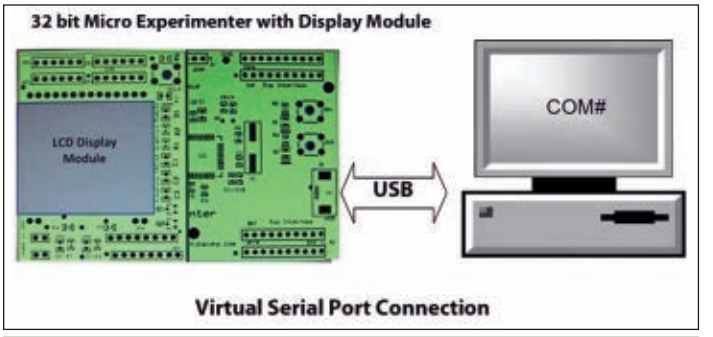


FIGURE 2. Block diagram.

We will explore in detail how the CDC can be used to provide virtual serial communications between a PC and the Experimenter. For demos, we will use the PS/2 keyboard, a rotary knob, and analog data sensor values as data sources to the PC. We will also make use of the PC and its keyboard for terminal operations. We will embark on a somewhat deep journey into Microchip's USB framework, but I promise it will be worth it. After reading this article and trying the experiments, you will have an understanding of how to use the Experimenter to emulate a serial port with USB. Again — as in all articles in this series — a general familiarity with the C language is required.

The Experiment Demos and Setup

The demo applications show how the PIC32 family CDC serial function driver provides a virtual UART to emulate a legacy serial COM port to the host PC. This approach will illustrate several advantages to the user:

- It has little or no impact on the PC software (since drivers are in place already).
- No special external hardware chip sets are required, like FTDI (uses internal USB peripherals within the PIC32).
- Firmware modifications to the existing application code are minimal; only small changes are needed for the virtual serial port and they are provided as part of the USB firmware framework written in C.

We will cover four distinct demo experiments that may be of direct use in your future projects:

- **PS/2 Keyboard to USB Demo** – This demo uses data originating via a PS/2 keyboard connected to the Experimenter to display keystrokes both on the PC, as well as on the Experimenter Universal Graphics Module. Uses a Mini-Kit module.
- **PC to Experimenter Display USB Demo** — This demo

displays data originating via the PC keyboard (using a terminal program) and displays it on the Experimenter LCD.

- **Analog Sensor Data USB Transfer Demo** — This demo sends a text string representing local Experimenter ADC digitized data to the PC when the SW1 pushbutton is pressed on the Experimenter.
- **Rotary Encoder Knob USB Service Demo** – This demo sends a rotary encoder knob rotation value and direction update from the Experimenter to the PC. Uses a Mini-Kit module.

For the demos, we use both the Mini-Kit with Rotary Encoder and the PS/2 interface as data interfaces. **Figure 3** shows the Mini-Kit with a PS/2 keyboard. The +5V is used to drive the PS/2 keyboard, and it can also be used as a power source for the Experimenter itself. A hook-up diagram (**Figure 4**) shows the connections between the Mini-Kit and Experimenter. We will use the Universal Graphics Display as a display option. On the PC side, we use a terminal emulator program. (All the supplemental hardware was described in earlier Experimenter articles.)

There are five key technical needs that must be addressed in order to achieve the virtual serial port. None of these are difficult, but all must be considered to get your virtual port working. We'll cover each of the following in more detail:

1. PIC32 USB peripheral.
2. Microchip USB stack.
3. Main code within your program.

FIGURE 3. Mini-Kit.

4. Microchip UART CDC API (application programming interface).
5. Setting up your PC serial communications.

1. The PIC32 USB Peripheral

The first component is the USB peripheral hardware. A block diagram is shown in **Figure 5**. This peripheral is standard for Microchip's entire line of USB enabled microcontrollers.

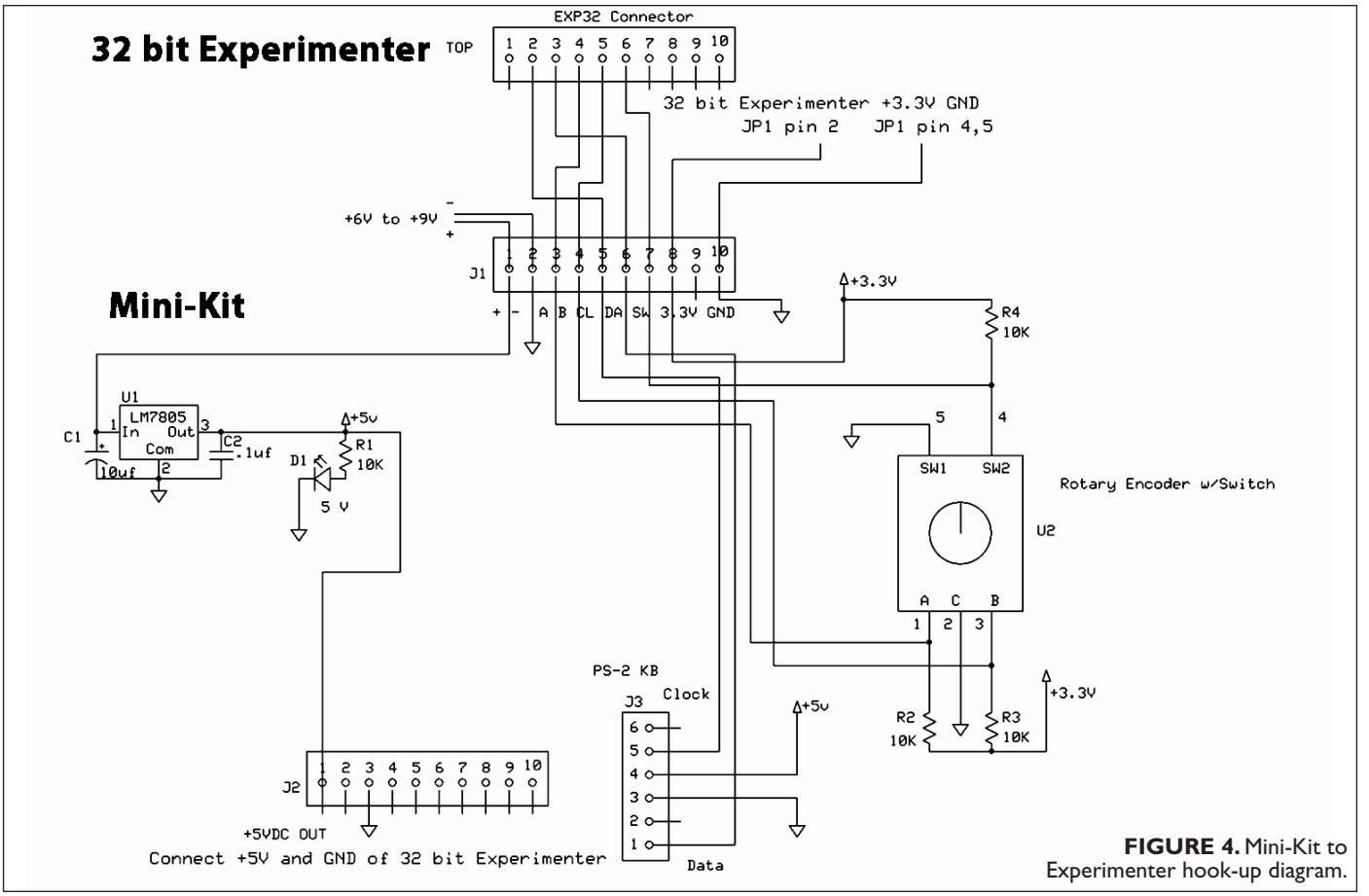


FIGURE 4. Mini-Kit to Experimenter hook-up diagram.

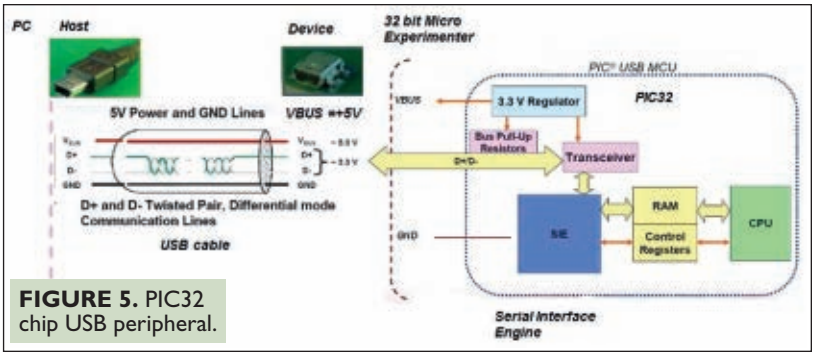


FIGURE 5. PIC32 chip USB peripheral.

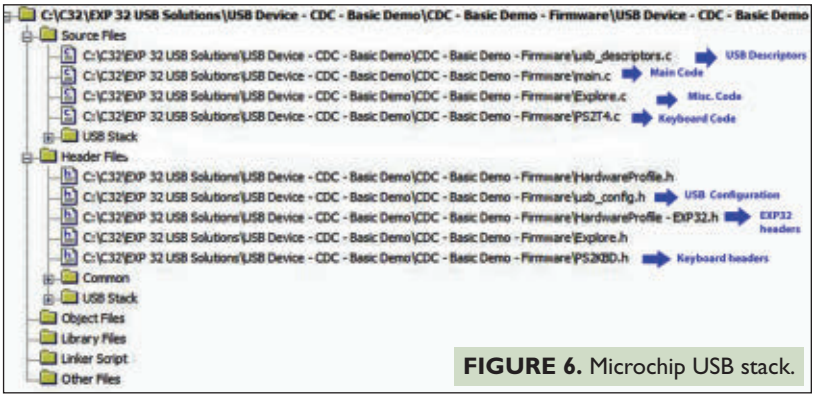

C:\C32\EXP 32 USB Solutions\USB Device - CDC - Basic Demo\CDC - Basic Demo - Firmware\USB Device - CDC - Basic Demo
Source Files
C:\C32\EXP 32 USB Solutions\USB Device - CDC - Basic Demo\CDC - Basic Demo - Firmware\usb_descriptors.c
USB Descriptors
C:\C32\EXP 32 USB Solutions\USB Device - CDC - Basic Demo\CDC - Basic Demo - Firmware\main.c
Main Code
C:\C32\EXP 32 USB Solutions\USB Device - CDC - Basic Demo\CDC - Basic Demo - Firmware\Explore.c
Misc. Code
C:\C32\EXP 32 USB Solutions\USB Device - CDC - Basic Demo\CDC - Basic Demo - Firmware\PS2T4.c
Keyboard Code
USB Stack
Header Files
C:\C32\EXP 32 USB Solutions\USB Device - CDC - Basic Demo\CDC - Basic Demo - Firmware\HardwareProfile.h
C:\C32\EXP 32 USB Solutions\USB Device - CDC - Basic Demo\CDC - Basic Demo - Firmware\usb_config.h
USB Configuration
C:\C32\EXP 32 USB Solutions\USB Device - CDC - Basic Demo\CDC - Basic Demo - Firmware\HardwareProfile - EXP32.h
EXP32 headers
C:\C32\EXP 32 USB Solutions\USB Device - CDC - Basic Demo\CDC - Basic Demo - Firmware\Explore.h
C:\C32\EXP 32 USB Solutions\USB Device - CDC - Basic Demo\CDC - Basic Demo - Firmware\PS2KBD.h
Keyboard headers
Common
USB Stack
Object Files
Library Files
Linker Script
Other Files

FIGURE 6. Microchip USB stack.

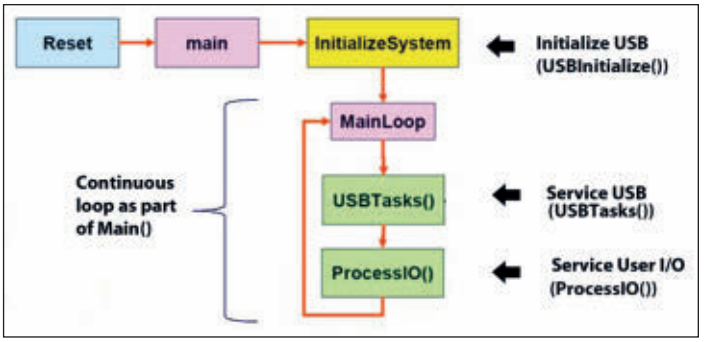


FIGURE 7. Generic Main function flow.

Note that the peripheral uses the USB bus supply voltage of +5V to sense the USB bus connection and to regulate and drive its data lines which are a +3.3V differential level. A key hardware component within the USB peripheral is the SIE or Serial Interface Engine. The SIE off-loads the PIC32 CPU by directly handling all USB activity. The SIE communicates to the PIC32 through internal RAM. It automatically does conversions from serial to parallel between serial USB bits and parallel CPU memory, and performs USB communications error checking.

2. The Microchip USB Stack

The Microchip USB framework is similar for all USB applications and it is the second consideration for the virtual serial port. A project view from MPLAB is captured for the USB to PS/2 keyboard USB demo. There are Main, Keyboard (PS2T4), and USB descriptor files and associated header files, including usb_config.h. Most of what we'll be concerned with is the Main file.

Let's discuss USB descriptors. Every USB device must provide a set of data structures called descriptors that give details to the host about how to use it. In general terms, the USB descriptors can be thought of as belonging to one of three different groups: those describing the overall device, those describing possible device configurations, and those providing user-readable information.

Each USB device has one and only one descriptor in the first group – the device descriptor. It uniquely identifies the device and gives the number of possible configurations. Each configuration (the second group) has its own set of descriptors describing the details of that configuration. User-readable information is kept in the string descriptors, making up the third group. All descriptors are already pre-defined using the Microchip firmware stack.

3. The Application Main Loop

Since most of the CDC USB related code is already in place within the Microchip framework, our user focus will be on the main function code.

To begin with, the main function must call USBInitialize API once. This is part of the initialize system block in **Figure 7** and it handles everything necessary to initialize the USB firmware stack. Once initialized, there are certain rules to follow to insure that the USB is properly serviced within the main function. This is accomplished by calling the C function USBTasks () once each time through the main loop. The USBTasks routine manages the state of the USB firmware stack and performs the necessary steps required by events that occur on the bus.

Finally, to service the user-specific defined I/O for the end application, we need to call the C function ProcessIO () (see **Figure 7**). This is the flow chart that the USB framework uses for Main code and is the one we will be following throughout the demos. This arrangement is described as cooperative multitasking and is implemented using a continuous loop in C code. For this loop, the user has to insure that the ProcessIO() does not unduly occupy significant CPU processing time. This occurs when the CPU delays service during ProcessIO() from the USB for greater than 1.8 milliseconds. While ProcessIO() is executing, it cannot consume CPU operations beyond 1.8 milliseconds. If this is done, it will cause an inadequate update service to the USB. When the ProcessIO() operates in this manner, it is designated to be a "blocking function." They are not allowed because they can cause USB functional problems.

To prevent this, Microchip recommends that the ProcessIO() be implemented as a "state machine design." This means that ProcessIO() is broken down into a number of discrete steps where each step consumes only a limited amount of loop time. This state machine is "non-blocking" and keeps track of what steps have been done and which ones still remain, during every pass through the main loop.

To help us visually understand blocking during the ProcessIO, a blink LED function is called. The blink

function simply toggles the two LEDs on the Experimenter. If the system is operating properly and ProcessIO() is non-blocking, then these LEDs should be blinking at a fairly regular rate. If ProcessIO() blocking occurs, then the LEDs may stop blinking or blink fairly unevenly.

Keep in mind that the blinking only starts once the Experimenter has been hooked up to the PC and is registered with the PC driver (USB jargon "enumerated").

4. The Virtual UART API

The CDC class within the Microchip USB stack supports the virtual UART API. These are the five functions that you will use in your ProcessIO(). By invoking the functions within this API, users can emulate a UART that both transmits and receives data to a PC. We will look at this API more carefully in the demos. The complete API is as follows. The choice of selecting which function in the API to use depends on several factors in the user's application. For instance:

- Is the string of data null-terminated?
- Is the length of the data string known?
- Is the data source located in program memory or in RAM?

A more detailed description is covered here:

- **mUSBUSARTisTxTrfReady()** — Is the driver ready to accept to accept a new string to write to USB?
- **putrsUSBUART ("string")** — Write a null-terminated string from program memory to the USB.
- **putsUSBUART ("string")** — Write a null-terminated string from data memory to the USB.
- **mUSBUSARTTxRom (data from flash, length)** — Write a string of known length from program memory to the USB.
- **mUSBUSARTTxRam (data from ram, length)** — Write a string of known length from data memory to the USB.
- **getsUSBUSART (receive buffer, length)** — Read a string from the USB.

5. PC Serial Port Setup

Finally, the last component is setting up the PC for a serial port. The port will extend the existing COM port portfolio on a PC host to a new COM port. In our demo, we will configure the serial port at a default 9600 baud, eight-bit, no parity, one stop bit, and with no hardware handshake (9600N81). Other configurations are possible. A block diagram of the Experimenter to PC setup is shown in **Figure 9**. An install process is required for the PC terminal to register the Experimenter USB as a virtual serial COM port on the PC. Once demo firmware is programmed into the Experimenter, the user should connect the board to the PC USB and follow the on-screen instructions to install the default (OS-provided) driver on the PC. The demo application will show up as a new COM port (number assigned by the OS).

Select this COM port from within the PC terminal emulator application. A number of PC terminal applications can be used like HyperTerminal or Tera Term,

```
void putrsUSBUSART(const rom char *data);

void putsUSBUSART(char *data);

void mUSBUSARTTxRom(rom byte *pData, byte len);

void mUSBUSARTTxRam(byte *pData, byte len);

byte getsUSBUSART(char *buffer, byte len);
```

FIGURE 8. CDC virtual UART API.

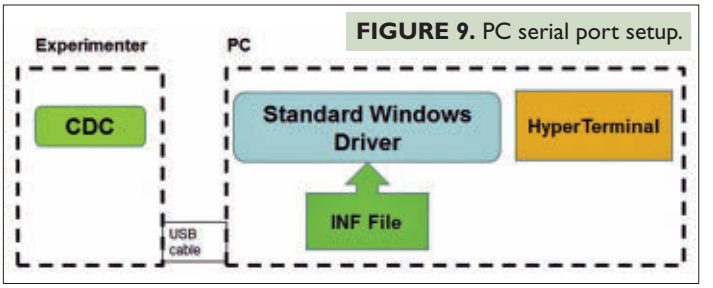


FIGURE 9. PC serial port setup.

```
void ProcessIO (void)
{   BLINKUSBStatus ();          //blink Experimenter LEDs to USB Status
    if ((USBDEVICEState < CONFIGURED_STATE) || (USBSuspendControl==1)) return;   // insure USB connected
    if (USBUSARTIsTxTrfReady() )    // check if USB ready to transmit
    {
    if (getcKBD())                  // test is keyboard has key ready
      {
        MyKey[0] =c;                //retreive key
        putUSBUSART (MyKey,1);      // output key to USB using API
        putcV (MyKey[0],1);         // display key on LCD
        dumpVmap();
      }
    }
    CDCTxService();                 // force USB transmit servce
}
```

FIGURE 10. USB keyboard ProcessIO().

or use a Visual Basic (VB) Net 2008 GUI that is available with the demos for download. The VB GUI application allows communication with a serial port. However, the VB version will require you to download and install Visual Basic Express 2008 edition which is free. Whatever your selection of terminal application is, a registry file or INF needs to be installed. The INF file is also included with the demos.

Once you connect your Experimenter USB to the PC, the Windows OS requires a software driver be installed for each new COM port. The Windows OS "Install Wizard" offers two possibilities: searching the Web or browsing your computer for the correct driver. The optimal choice is to browse your computer and navigate to the downloaded demo folder where a copy of the INF file is located. Select this driver and direct Windows to do the install. These steps were covered and illustrated in an article in the Oct '11 issue entitled "Legacy Communication using the 32-bit Experimenter."

Virtual Serial Port Demos

Now that we understand all the important theory and technical considerations, let's apply it. In all the following examples, the focus will be on ProcessIO(). This is where the magic happens. For the most part, all the rest of the USB project file is similar. Where any new files are introduced, they will be discussed. As mentioned earlier, in all examples we will assume the use of the Universal Graphics Card. This is an Arduino compatible interface board that plugs into the Experimenter. Also, when the rotary encoder or PS/2 keyboard is used, the Mini-Kit is assumed. Again, a hook-

```
void ProcessIO (void)
  BYTE numBytesRead;
  BYTE count, index;

BLINKUSBStatus ();      //blink Experimenter LEDs to USB Status
If ((USBDEVICEState < CONFIGURED_STATE) || (USBSuspendControl==1)) return;

      if (mUSBUSARTIsTxTrfReady () ) // tx ready?
      {
            numBytes =0;
        numBytesRead = getsUSBUSART(USB_In_Buffer,8) ; //read USB input buffer
        if (numBytesread !=0 )
        {
        for (index =0; index <numBytesRead; index++)
        {
            myc =USB_IN_Buffer [index];   //read each character and write to display
             putcV(myc);
        }
       putUSBUSART( USB_In_Buffer, numBytesRead); //echo back received characters
       dumpVmap();  //refresh display
        }
CDCTxService() ; } //end ProcessIO
```

FIGURE 11. PC to Experimenter demo.

```
void ProcessIO (void)
{    float y;
     int adc_value ;
     char out [12] ;
     BLINKUSBStatus ();       //blink Experimenter LEDs to USB Status
     If ((USBDEVICEState < CONFIGURED_STATE) || (USBSuspendControl==1)) return;
     if (buttonPressed)       // is button pressed?
     {    if (stringPrinted ==FALSE)
          {    if (mUSBUSARTIsTxTrfReady () )  // check Tx ready
               {  adc_value = readADC (AN4);   // digitize pot
                  y =(float) adc_value*.003;     //convert pot data to voltage
                  sprintf(out, "AN4 =%1.1f \r\n",y); //format pot data into ASCII
                  putsUSBUSART(out);  //output to USB
                  stringPrinted =TRUE;
                  putsV(out);   //output to display
                  dumpVmap();
               }
          }
     } else
     {   stringPrinted = FALSE;
     }
     CDCTxService();
     } //end ProcessIO
```

FIGURE 12. Analog data demo.

```
void ProcessIO (void)
{    BLINKUSBStatus ();       //blink Experimenter LEDs to USB Status
     If ((USBDEVICEState < CONFIGURED_STATE) || (USBSuspendControl==1)) return;

     if (ROLD !=RCount)   //rotation change
     {
          if (stringPrinted ==FALSE)
          {
               if (mUSBUSARTIsTxTrfReady () )
               {
                  sprintf(out, "Count =%d \r\n",y);  //format rotation
                  putsUSBUSART(out);   //output to LCD
                  stringPrinted =TRUE;
                   ROLD= RCount;    //update rotation value
                   AT (0,0)    //postion to 1st line of display
                  putsV(out);   //output to display
                  dumpVmap();
               }
          }
     } else
     {   stringPrinted = FALSE; }
     CDCTXService () ;
     } //end processIO
```

FIGURE 13. Rotary ProcessIO.

up diagram is provided in **Figure 4** that shows how to connect the Mini-Kit to the Experimenter. Let's get started.

PS/2 Keyboard to USB Demo

This demo uses the PS/2 keyboard as a data source. It uses the Mini-Kit that is connected to the Experimenter. Data typed on PS/2 keyboard is displayed simultaneously on both the Experimenter LCD, as well as the PC terminal. Open EXP32KeyboardLCD.mcp in the keyboard demo example code folder. Build and download code using the Microchip IDE and PICKIT3 debugger/programmer or equivalent. Both an include file and driver code designated PS2T4 for the keyboard driver are contained in the project workspace. The ProcessIO() function in Main is as follows:

The ProcessIO blinks the Experimenter LEDs based on the USB connection status. It then determines if the USB is connected to a PC before proceeding. If connected, it checks the USB transmitted status; if the transmit is ready, it retrieves a key and sends it out over USB using API **putsUSBUART().** As a side note, before transmitting, it calls **USBUSARTisTxTrFReady().** The key is also displayed on the LCD display. Before exiting, the **CDCTxService()** function is called to initiate a transmit service. As another side note, the **getcKBD()** function (to retrieve a keyboard key c) was originally written as a blocking function and had to be rewritten to incorporate a state machine structure for proper USB operation.

PC to Experimenter USB Display Demo

This demo simply displays characters received from the PC over USB by the Experimenter and displays them on the LCD display. The workspace is included in the terminal demo folder. Open EXP32HyperterminalLCD.mcs, then build and download to the Experimenter. The ProcessIO() is as follows: The ProcessIO() checks if the USB transmitter is ready and if so, reads the USB buffer through **API getsUSBUSART()** and then echoes back the received character through a Transmit API **putsUSBUART()**, as well as writes to the Experimenter display.

Analog Sensor Data USB Transfer Demo

This demo uses a 10K pot tied between +3.3 VDC and GND with a pot wiper connected to analog input 4 or AN4 of the PIC32, or pin 8 of the Experimenter JP2 connector. For power to the pot, it uses the externally available +3.3V output at pin 10 of the BOT Experimenter connector and GND output from pin 9 of BOT. The pot value is digitized via the Experimenter ADC and then reported in ASCII format to the PC over USB on demand. The demand in this case occurs when SW1 pushbutton of the Experimenter is depressed. This analog demo utilizes the following ADC library which is included in ADC.h and ADC.C in the demo workspace:

- **int readADC(int ANpin)** — Perform ADC operation on designated pin and return digitalized result.
- **initADC(int ANpin)** — Initialize ADC operation using designated pin as the analog input.
- **ADCoff(void)** — Turn off ADC peripheral.

The workspace is included in the analog demo folder. Open EXP32ADC.mcs, then build and download to the Experimenter. The ProcessIO() is as follows: In this example, we

check the Experimenter pushbutton. If it is depressed and the USB is ready to transmit, the pot value is transmitted over USB (using API **putsUSBUART()**) and is also displayed on the Experimenter LCD. We also make use of the stdio.h C library to help with data formatting and the analog library to digitize the pot value at the AN4 pin.

Rotary Encoder Knob USB Service Demo

This demo uses the Mini-Kit rotary encoder as the data source to the Experimenter. Rotary encoder data is captured as a string containing direction CCW (-) or CW (+) and accumulative encoder rotation counts to the PC. The data string originating on the Experimenter will be displayed on both the Experimenter LCD, as well as the PC terminal. No additional software files are included in the demo workspace. Rotary encoder device drivers are integrated into the Main function as an interrupt service. The workspace is included in the rotary demo folder. Open EXPROTARY.mcs, then build and download to the Experimenter. The ProcessIO() is as follows:

In this example, we first look for a rotary count difference before proceeding. If there is a difference, we format the string, display and output it, and update the new rotary count internally.

In Conclusion

We've embarked on long journey in order to understand how to create a virtual serial port to a PC using the Experimenter, its USB interface, and Microchip's USB firmware stack. A number of demos were covered, with an introduction to a new analog library for the Experimenter ADC. We can now maintain required legacy communications to a PC using this new bag of tricks, and with the five steps covered, we now have a valuable tool set that creates a serial port with minimal hardware and software impact to any future Experimenter designs. Until next time, happy 32-bit processing! **NV**

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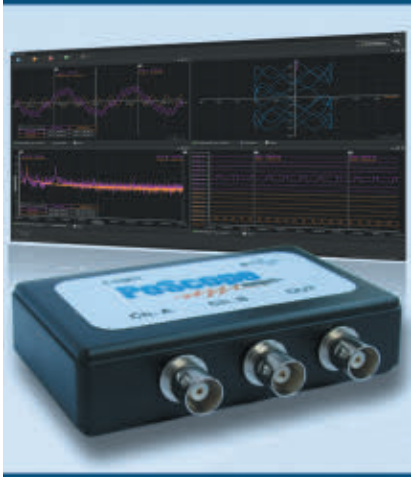

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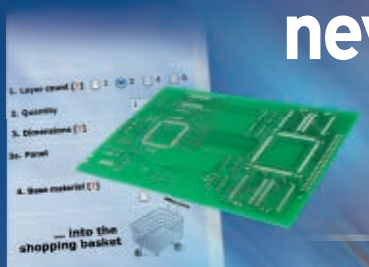

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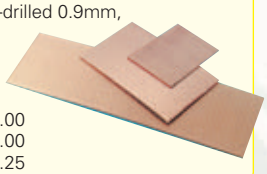

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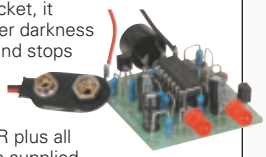

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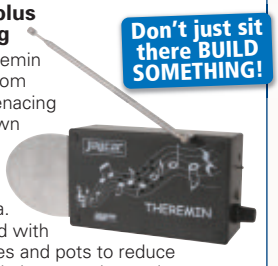

- Complete kit contains PCB with overlay, pre-machined case and all specified components
- PCB: 145 x 85mm

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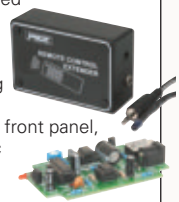

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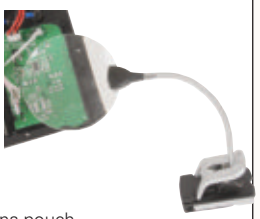

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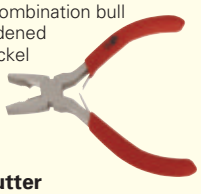

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CLC CULTURE

When the six-pin PIC10F series of PICs were announced, I jumped all over those tiny microcontrollers, turning them into tiny programmable logic gates and clock sources. It was really neat to be able to synthesize a specialized logic function using only the six-pin PIC10F and a dabble of C code. However, once the PIC10F's program space was allocated for logical purposes, there were no CPU cycles left for an application. In addition, the coded logic was only effective when the CPU was fetching and executing mnemonics.

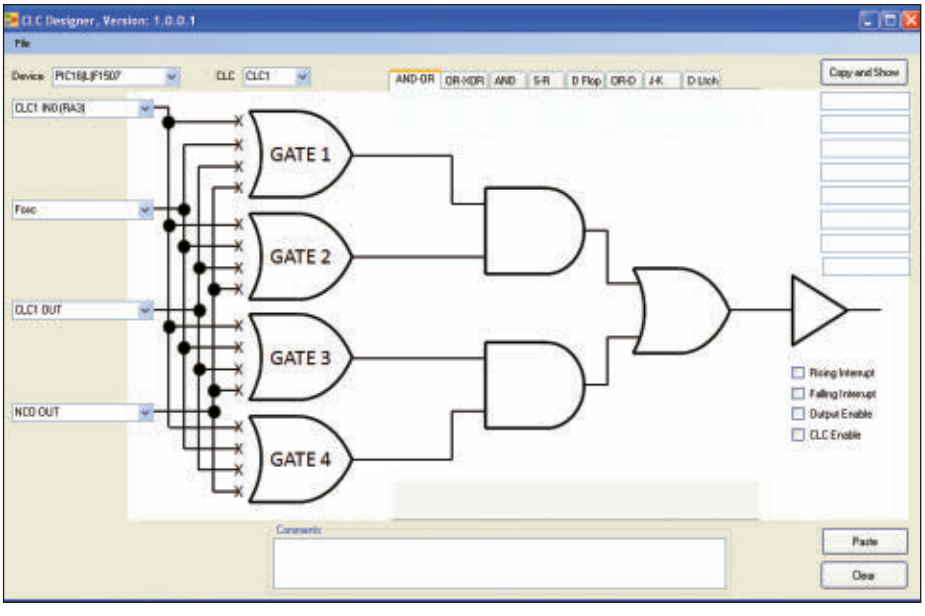
CPLDs and FPGAs are neat to work with, as well. If you have a number of complex logic functions to implement, a CPLD or FPGA is usually the ticket to success. To make programming your complex logic algorithms into a CPLD or FPGA worth the effort, the logic algorithms must be too complex or too large for a microcontroller to execute inside of its application firmware.

Today's PIC microcontrollers are robust enough to stand alone in a majority of applications. However, there are times that a TTL or CMOS logic IC has to be thrown into the hardware design to do that one little bit of combinatorial logic processing that you just couldn't fit into your main application. The additional logic IC doesn't come free. You have to provide additional board space and wiring resources to power the IC, and route its input and output signals. Wouldn't it be great if you could mix a set of combinatorial logic components in with your microcontroller and place them all under the same silicon umbrella?

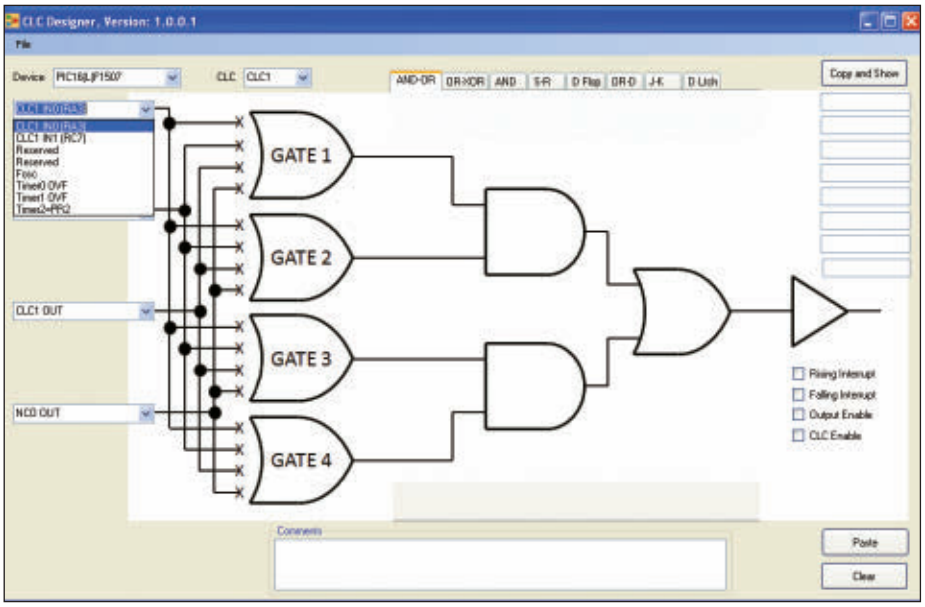
CONFIGURABLE LOGIC CELL TECHNOLOGY

Imagine a mini CPLD embedded into a PIC that can work independently of the CPU. The PIC-based mini CPLD has multiple input paths that can be selected via firmware to feed a number of differing combinatorial logic arrangements, which are also firmware selectable. Microchip has this technology and the mini CPLD I've described is in reality called a Configurable Logic Cell or CLC. The CLC is standard equipment on PIC16F1507 and PIC16LF1507 microcontrollers. As of this writing, the PIC16(L)F1503 and PIC16(L)F1507 family members can be had via Microchip DIRECT and authorized Microchip distributors. The enhanced PIC16(L)F1508/9 parts are listed as future products. The CLC culture can also be found as touchable silicon in the PIC10(L)F320 and PIC10(L)F322. You can still use the PIC10F parts as combinatorial logic devices and run an application to boot.

Standard CLC configurations include: AND-OR, OR-XOR, AND, S-R, D, OR-D, J-K, and D LATCH. All of the logic block configurations are front-ended by a quad of four-input OR



■ SCREENSHOT 1. Clicking on various gate inputs and outputs allows either a connection or an inversion. Connections, inversions, device types, and logic configurations in the template are collected and converted into CLC firmware.



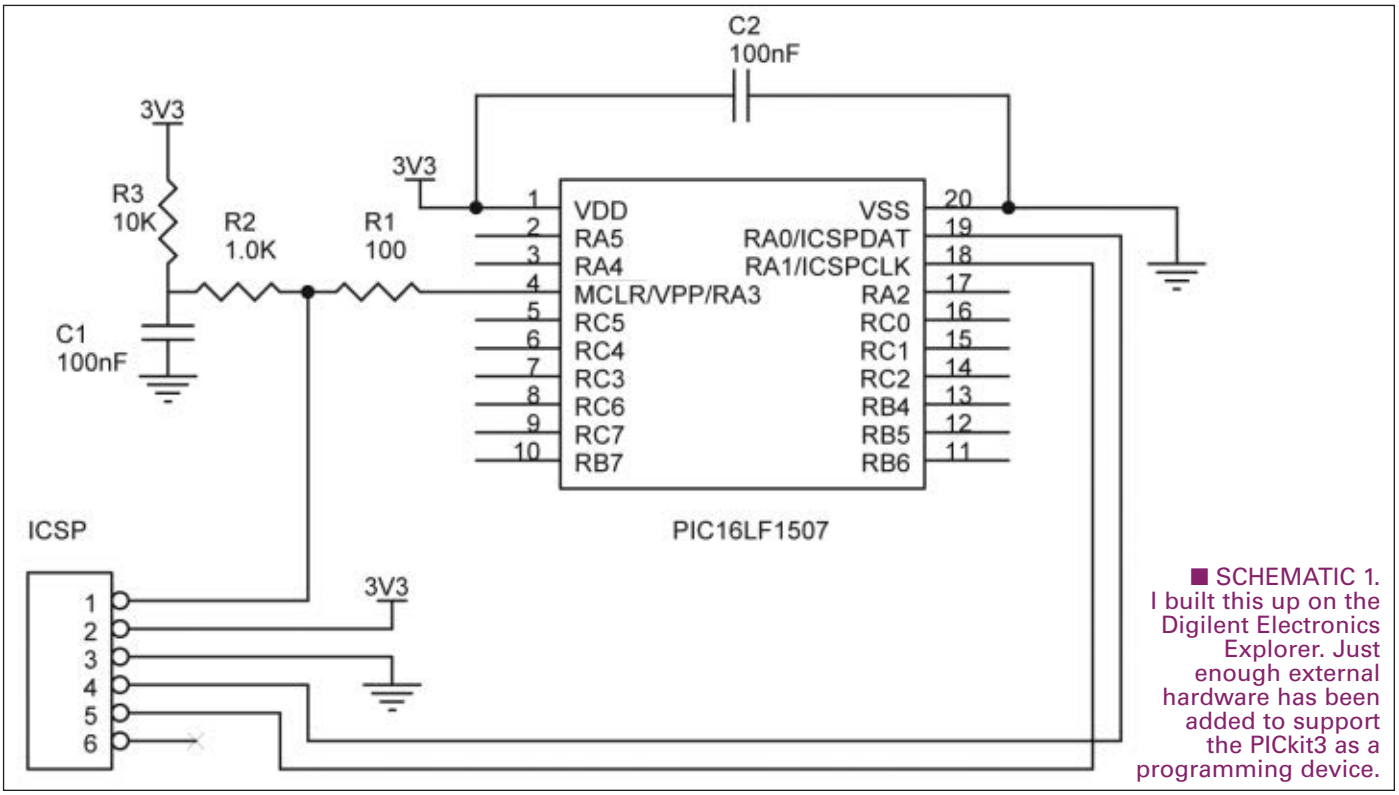
■ SCREENSHOT 2. Multiple input source configuration mappings can be obtained by utilizing the alternate input sources in the pull-down menus.

gates. Each of the four OR gate inputs can be assigned as active inputs by manipulating the associated CLC registers in firmware. Every input to each of the four OR gates can also be programmed with an inverted output. In addition, the outputs of the four gates can be configured to invert their signals. CLC input sources are programmable and include PIC16(L)F1507 I/O pins, timers, internal oscillators, internal PWM modules, and the NCO (Numerically Controlled Oscillator). In devices that contain multiple CLC modules, the CLC outputs can be used as inputs for other CLC modules. The PIC16LF1507 — which will be the object of our affection — contains a pair of CLC modules.

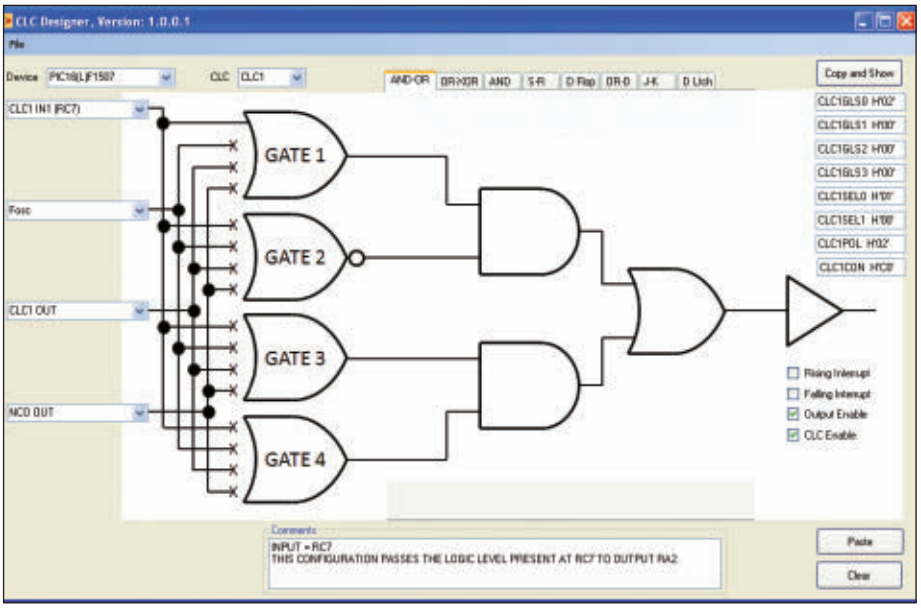
A CLC PRIMER

This is one of those rare times that I can actually bring print to life. For us to keep the print hopping, go to the Microchip website and download the CLC Designer application. Once you have downloaded and installed CLC Designer, you can physically duplicate the procedures I will be executing with words and screenshots.

In **Screenshot 1**, I've kicked off CLC Designer and selected the PIC16(L)F1507 as the target microcontroller. CLC Designer does a bit more than just display the CLC gate configurations and input connections. CLC Designer translates the gate input sources and connections, along with the selected logic configuration into CLC firmware that we can simply paste into our C or assembler source code. Note that we can assign any of the four input sources to any of the four gates. In **Screenshot 2**, I've pulled down the topmost source input menu to reveal the other gate input source options at this level. We have a choice of both of the PIC16(L)F1507's I/O pin inputs plus the internal oscillator and the timers. The remaining gate input selections are populated to allow a large number of gate input source configurations.



■ SCHEMATIC 1. I built this up on the Digilent Electronics Explorer. Just enough external hardware has been added to support the PICkit3 as a programming device.



■ SCREENSHOT 3. The logic has been voiced and the connections have been made. All that's left to do is run the C code that was generated by this screenshot.

CLC DESIGNER BASICS

Let's attach an external signal coming in on CLC1 IN1 to GATE 1 and pass it through an AND-OR logic block. We'll extract the output signal at the CLC1 output. Basically, what comes into CLC1 IN1 appears at the CLC1 output, which we will allow to be presented on a PIC16(L)F1507 I/O pin. If you consult the PIC16(L)F1507 datasheet, you'll find that CLC1 IN1 is associated with RC7, and CLC1 appears on I/O pin RA2. If you're wondering why we didn't come in on CLC1 IN0, take a look at **Schematic 1** and recall my First Rule of Embedded Computing which says that nothing is free.

In our application, I/O pin RA3 is being used as the MCLR pin. So, if we want to designate an external input for CLC1, we must use CLC1 IN1. Going with what we know at the moment, we will select CLC1 IN1 (RC7) as the external input source for GATE 1. A mouse click on the "x" associated with CLC1 IN1 makes the "connection" with GATE 1.

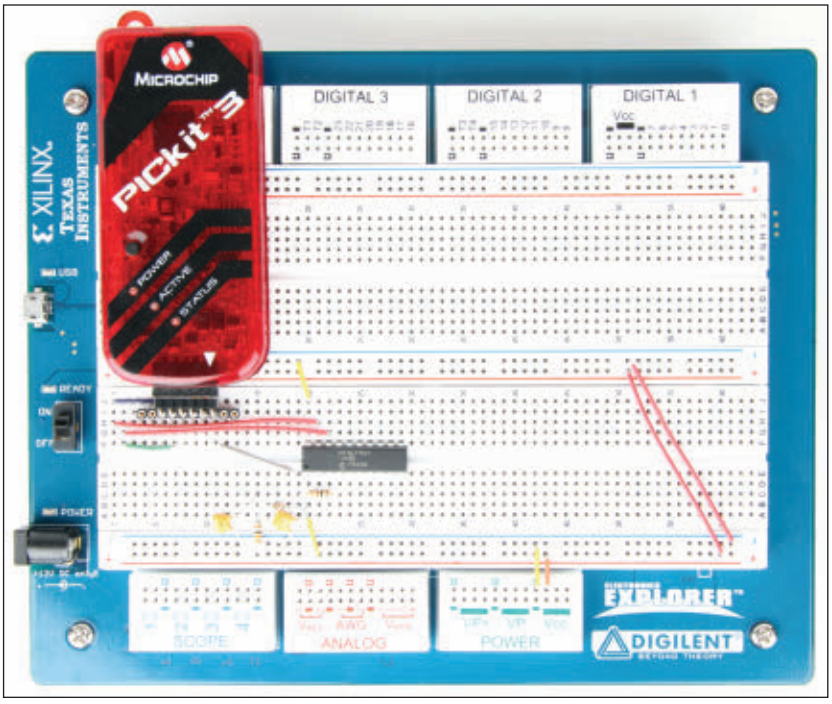
Let's stop here and use **Screenshot 1** to analyze what will or will not happen. GATE 1 is an OR gate. Any logically high input applied to any of GATE 1's inputs will result in a logical high on the output of GATE 1. CLC Designer forces the output of any GATE with no assigned inputs as logically low. If we apply a logical high to CLC1 IN1, GATE 1's output will go logically high. Since there are no inputs attached to GATE 2, the output of GATE 2 is logically low. The outputs of GATE 1 and GATE 2 feed an AND gate. Remember that we want to pass the logic level at CLC1 IN1 to the output of CLC1.

In that GATE 2's output is logically low, the output of the AND gate will also be driven logically low regardless of GATE 1's output logic level. As you can see in **Screenshot 1**, the output of both AND gates feeding the final OR gate is logically low. Thus, a logical low level is seen at the CLC1 buffer output. That's not what we want.

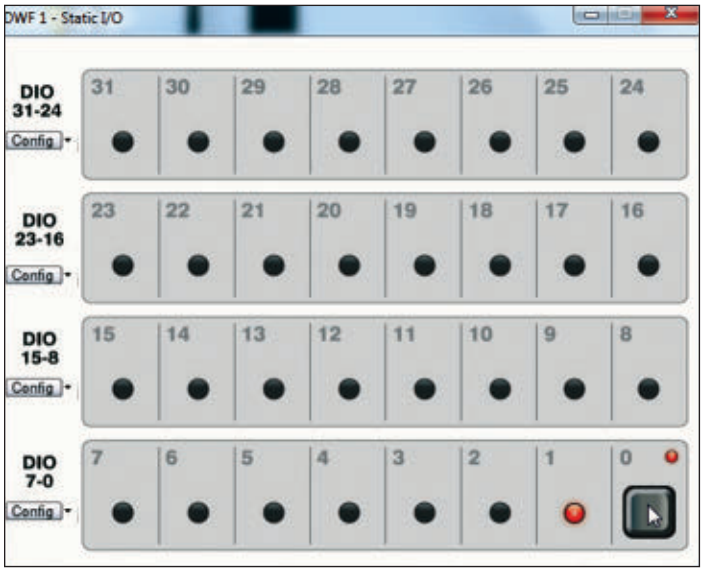
To pass the CLC1 IN1 logic level through the AND gate, we must force GATE 2's output logically high. That's easily done by simply clicking on the GATE 2 output. An inversion symbol is attached to the output of GATE 2, transforming it into a NOR gate with a logically high output state. To pass the CLC1 IN1 logic level to RA2 (CLC1 output), we must enable the CLC1 output. Plus, we need to make sure that CLC1 is enabled. Both of the aforementioned operations are easily performed with a couple of mouse clicks on the Output Enable and CLC Enable check boxes.

The CLC Designer's computed CLC register entries can be displayed by clicking the Copy and Show button. We can also enter some descriptive comments at this time in the Comments window. Finally, we save the final template information shown in **Screenshot 3** as a C include file. We'll call it *pushbutton-clc.inc*. The nature of the filename will become obvious shortly. Here's the C code we generated using CLC Designer:

```
// File: pushbutton-clc.inc
// Generated by CLC Designer, Version:
// 1.0.0.1
// Date: 12/15/2011 3:30 PM
// Device:PIC16(L)F1507

//  INPUT = RC7
```



■ PHOTO 1. Power supply, oscilloscope, voltmeter, power supply, and logic analyzer — all in less space than a laptop PC.



■ SCREENSHOT 4. The Digilent Electronics Explorer's virtual pushbutton is depressed and the virtual LED connected to the CLC output displays the logic level injected into the PIC16LF1507's CLC input by the pushbutton.

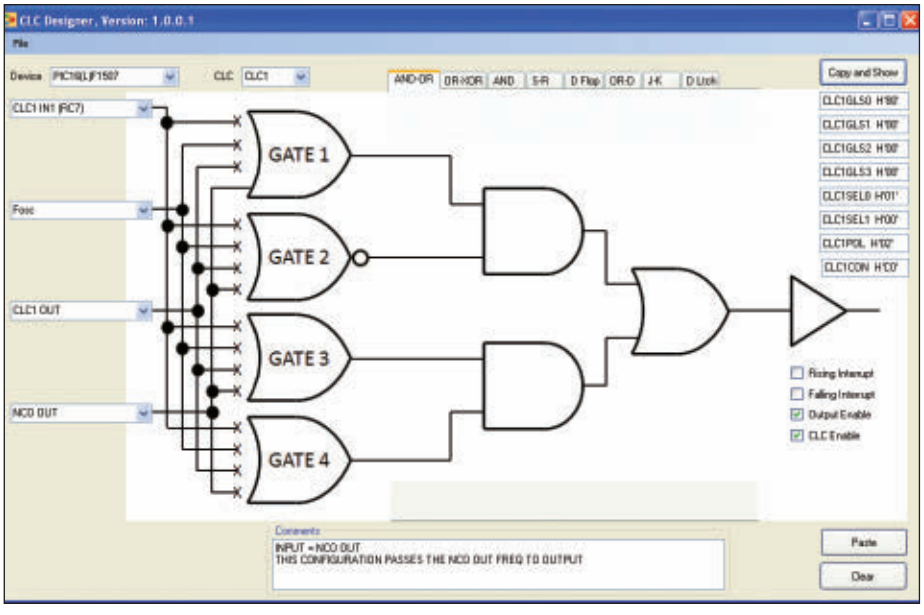
```
//  THIS CONFIGURATION PASSES THE LOGIC LEVEL
//  PRESENT AT RC7 TO OUTPUT RA2.

        CLC1GLS0 = 0x02;
        CLC1GLS1 = 0x00;
        CLC1GLS2 = 0x00;
        CLC1GLS3 = 0x00;
        CLC1SEL0 = 0x01;
        CLC1SEL1 = 0x00;
        CLC1POL  = 0x02;
        CLC1CON  = 0xC0;
```

If we want to recall this data using CLC Designer, we must leave the comments intact. CLC Designer uses some of the comment information to determine which PIC variant the code belongs to. Otherwise, the uncommented CLC register code is all our application source code needs. Now that we've verified our logic using the contents of **Screenshot 3**, let's fire up some electrons and prove out our logic with hardware and firmware.

Photo 1 includes a PICkit3 acting as a programmer and the electronic components drawn up in **Schematic 1**. The PIC16LF1507 and supporting electronics are built up on a Digilent Electronics Explorer. The Electronics Explorer allows us to use virtual pushbuttons and LEDs. Plus, the Explorer hardware and the WaveForms application combine to form a self-contained set of test equipment that includes voltmeters, a four-channel oscilloscope, power supplies, displays, and a logic analyzer.

I've configured the Electronics Explorer's DIO 0 as a pushbutton. DIO 1 is set up as a virtual LED. The virtual pushbutton toggles between a logically low and logically high state. DIO 0 is wired physically to the PIC16LF1507's RC7 I/O pin. So, when the pushbutton in **Screenshot 4** is clicked, a logical high is applied to CLC1 IN1. If our **Screenshot 3** logic assessment is correct, the virtual LED at DIO 1 connected to the CLC output (I/O pin RA2) will illuminate when the virtual pushbutton is depressed. The proof is shown in **Screenshot 4**. Here's the code:

```
#include <htc.h>

__CONFIG(FOSC_INTOSC & WDTE_OFF &
BOREN_OFF);

//FUNCTION PROTYPES
void init(void);

//INITIALIZE FUNCTION
void init(void)
{
        //Turn off ADC
ADCON0bits.ADON = 0;
        ANSELA = 0;
        ANSELB = 0;
        ANSELC = 0;
        //Set CLC output pin (RA2)
        TRISA = 0b11111011;
        TRISB = 0b11111111;
        //Set CLC input pin (RC7)
        TRISC = 0b11111111;

// File: pushbutton-clc.inc
// Generated by CLC Designer, Version: 1.0.0.1
// Date: 12/15/2011 3:30 PM
// Device:PIC16(L)F1507

//  INPUT = RC7
//  THIS CONFIGURATION PASSES THE LOGIC LEVEL
//  PRESENT AT RC7 TO OUTPUT RA2.

        CLC1GLS0 = 0x02;
        CLC1GLS1 = 0x00;
        CLC1GLS2 = 0x00;
        CLC1GLS3 = 0x00;
        CLC1SEL0 = 0x01;
        CLC1SEL1 = 0x00;
        CLC1POL  = 0x02;
        CLC1CON  = 0xC0;

}

void main(void)
```



■ SCREENSHOT 5. Just a couple of mouse clicks and some new comments is all it takes to plug the NCO into the CLC.

```
{
        init();
        SLEEP();
        while (1);
}
```

The compiler of choice is the HI-TECH C Compiler for PIC10/12/16 MCUs. The *init()* function disables the PIC16(L)F1507's analog-to-digital module and sets up the CLC registers. I've put the PIC16LF1507 to sleep to show that the CLC can operate while the CPU is in sleep mode.

The CLC is also capable of using internally generated signal sources. **Screenshot 5** depicts a CLC configuration that substitutes the NCO (Numerically Controlled Oscillator) output for our pushbutton. We already know that whatever the NCO emits as a signal will appear at the CLC1 output. Before we can see the NCO output, we must configure the NCO to generate a signal for us.

NUMERICALLY CONTROLLED OSCILLATOR PRIMER

The NCO module consists of a clock source, a 16-bit increment register, and a 20-bit accumulator. The 16-bit increment value is loaded into the accumulator on every clock cycle. The raw NCO signal is generated when the accumulator overflows with a carry. Since the NCO period changes in discrete steps, the resulting raw NCO signal is an average frequency.

In Fixed Duty Cycle (FDC) mode, the raw NCO signal is gated to a D flip-flop wired in divide by 2 mode. The output of the D flip-flop is a signal with a 50% duty cycle that has a frequency of one half of the input signal. The final NCO signal can be routed internally to the CLC or out to a PIC16(L)F1507 I/O pin. The 16-bit increment value is determined by manipulating this formula:

$$F_{OVERFLOW} \quad \frac{\textit{NCO Clock Frequency x Increment Value}}{2^n}$$

n = Accumulator width in bits

```
Where: FOVERFLOW = Accumulator Overflow Frequency
       NCO Clock Frequency = 16 MHz
       Increment Value = 16-bit Increment Value
       n = 20
       2^n = 1,048,756
```

For this discussion, we will use the maximum frequency of the PIC16(L)F1507's internal oscillator which is 16 MHz. We want to solve for Increment Value. So, we can do a little algebraic manipulation to arrive at this:

$$\text{Increment Value} = (2^n \times (2 \times F_{OVERFLOW})) \; / \; \text{NCO Clock Frequency}$$

Just in case you're wondering why $F_{OVERFLOW}$ is multiplied by 2, remember that we need to double the accumulator overflow count which becomes our NCO out frequency. To verify our math, let's set up our NCO to output a frequency of 1.0 kHz:

```
       Increment Value = (1,048,576 x (2 x 1000))
       / 16,000,000
       Increment Value = 131.072 or 0x83
```

Now that we have an increment value, let's apply it with some PIC16(L)F1507 C code. We'll begin by enabling the NCO output I/O pin:

```
       //Turn off ADC
ADCON0bits.ADON = 0;
       ANSELA = 0;
       ANSELB = 0;
       ANSELC = 0;
       TRISA = 0b11111011;
       TRISB = 0b11111111;
       //Set NCO output pin (RC1)
       TRISC = 0b11111101;
```

In that we are relying on the PIC16(L)F1507's internal oscillator, let's make sure it is configured to run at 16 MHz:

```
    OSCCONbits.SCS1 = 0;
    OSCCONbits.SCS0 = 0;
    OSCCONbits.IRCF3 = 1; //Set IRCF0-3 to run
                          //16 MHz
    OSCCONbits.IRCF2 = 1; //
    OSCCONbits.IRCF1 = 1; //
    OSCCONbits.IRCF0 = 1; //
```

To run in FDC mode, we must clear the NCO1CON's N1PFM bit. To let the NCO signal out of the PIC16(L)F1507's RC1 I/O pin, we must set the N1OE bit in the NCO1CON register. The NCO module is enabled and its output polarity is also controlled by bits in the NCO1CON register:

```
    NCO1CONbits.N1EN = 1;    //Enable the NCO
    NCO1CONbits.N1OE = 1;    //Enable the NCO
                             //output on RC1
    NCO1CONbits.N1POL = 1;   //Set polarity
    NCO1CONbits.N1PFM = 0;   //Enable FDC mode
```

Here's how we select the PIC16LF1507's HFINTOSC and set our NCO clock rate at 16 MHz:

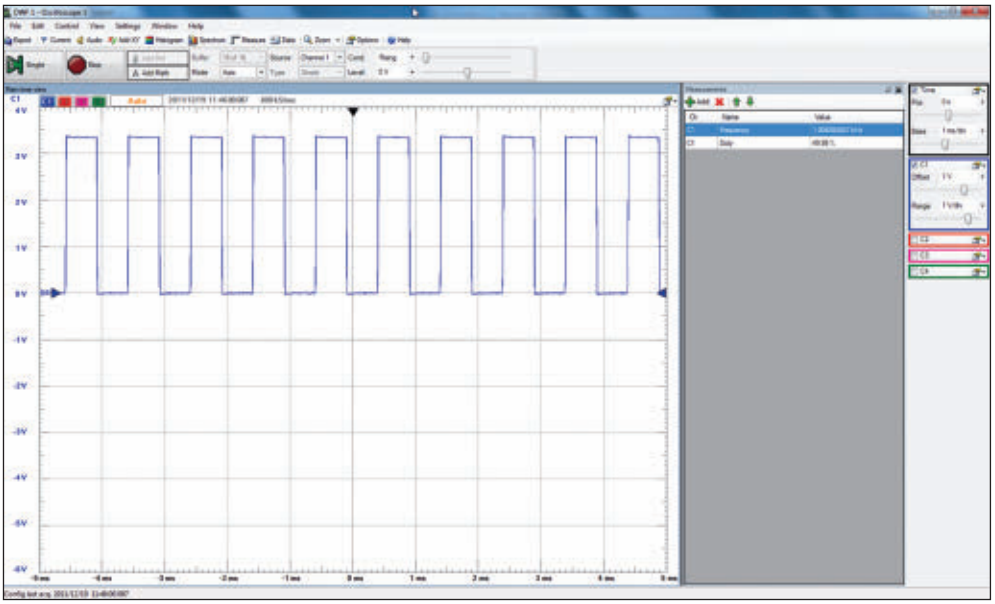
```
    NCO1CLKbits.N1CKS1 = 0;  //Select the HFINTOSC
                             //(16 MHz)
    NCO1CLKbits.N1CKS0 = 0;
```

Loading the NCO increment register with our calculated value of 0x83 produced an average NCO output frequency of 998 Hz. So, I decided to load 0x84:

```
    NCO1INCH = 0x00;
    NCO1INCL = 0x84;
```

The NCO code we've just written was added to the original *init()* function. The NCO module is also capable of running independently of the CPU. So, I used the same *main()* code that we used to run the CLC. With the PIC16(L)F1507's CPU sleeping, I used the Electronics Explorer's oscilloscope functionality to capture the NCO's output signal in **Screenshot 6**.

The NCO output is linear with respect to the increment value. Now that we've calculated the 1 kHz increment value, to get 2 kHz out of the NCO we simply double the 1



■ SCREENSHOT 6. 1.00488 kHz with a duty cycle of 49.99% ain't too shabby.

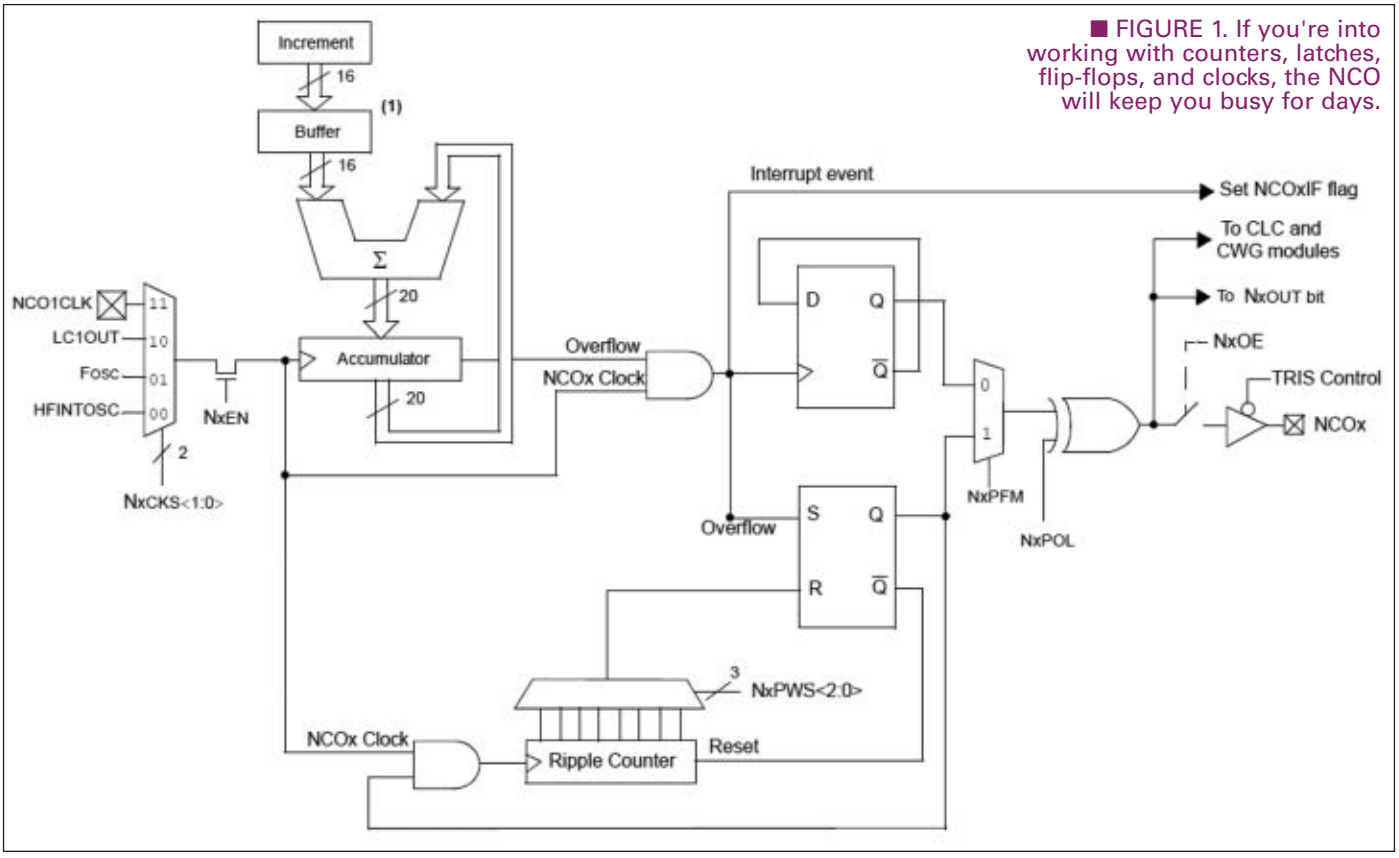
kHz increment value. This increment value resulted in an NCO output frequency of 1.997 kHz:

```
NCO1INCH = 0x01;
NCO1INCL = 0x06;
```

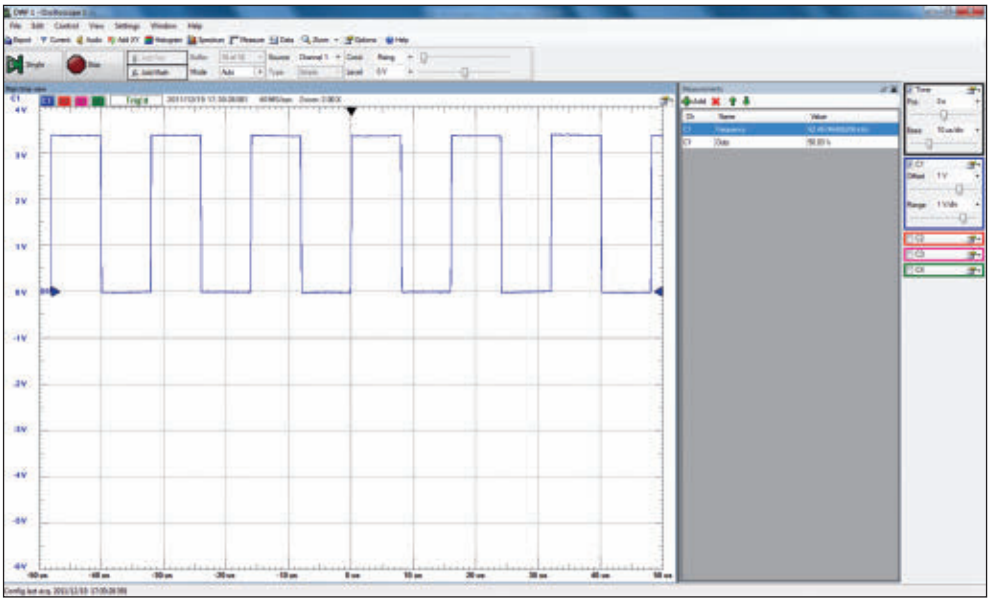
Loading the NCO increment register with 0x0107 produced 2.005 kHz. In either case, the duty cycle varied between 49.99 and 50.02%.

Thus far, we've been navigating in the upper half of **Figure 1**, which is a block diagram of the PIC16(L)F1507's NCO module. Let's flip that N1PFM bit and check out the NCO in Pulse Frequency (PF) mode. If you take another look at **Figure 1**, you will notice that PF mode uses the NCO's SR Latch instead of the D flip-flop. The best way to understand how the NCO works in PF mode is to create a square wave. Let's forget about the SR Latch for now and concentrate on the Ripple Counter. The Ripple Counter's time until overflow is determined by the value loaded into the N1PWS bits and the NCO clock frequency. In our case, the NCO clock is running at 16 MHz. The period of our NCO clock is 1/16 MHz which equates to 62 nS. If we set the Ripple Counter to overflow every 128 clock cycles, it will overflow in 8 µS with a 16 MHz clock input.

Note that the Ripple Counter can only count when the SR Latch is set. The SR Latch gets a set pulse with every overflow of the NCO accumulator. The accumulator overflow pulse is derived from logically ANDing the most significant bit of the 20-bit accumulator and the NCO clock. The accumulator overflow sets the SR Latch and forces the SR Latch Q output logically high. With Q logically high, the NCO clock



■ FIGURE 1. If you're into working with counters, latches, flip-flops, and clocks, the NCO will keep you busy for days.



■ SCREENSHOT 7. Figures don't lie.

is gated to the Ripple Counter input and the Ripple Counter begins to count. The NCO output is logically high at this point.

For the NCO to generate a valid pulse in PF mode, the accumulator overflow must not occur before the Ripple Counter completes its count sequence. When the Ripple Counter reaches maximum count, it resets the SR Latch forcing Q logically low. At this point, the Ripple Counter is reset by the output and the Ripple Counter count is inhibited. The output of the NCO will remain logically low until the accumulator overflows again. To generate that square wave, we will need the accumulator to overflow every 16 µS. The frequency associated with 16 µS is 62.5 kHz. Once again, we must use our $F_{OVERFLOW}$ formula to solve for Increment Value:

```
Increment Value = (1,048,576 x (62.5 KHz)) / 16 MHz
```

The Increment Value computes to 4,096, which is 0x1000. We don't have to do much to generate that square wave. Flip the mode bit, set the Ripple Counter runout, and load the Increment Register:

```
NCO1CONbits.N1PFM = 1;          //Change mode to PF

NCO1CLKbits.N1PWS2 = 1;         //Ripple Counter set
                                //for 128 clock
                                //cycles
NCO1CLKbits.N1PWS1 = 1;
NCO1CLKbits.N1PWS0 = 1;

NCO1INCH = 0x10;                //Increment Register
                                //loaded with 0x1000
NCO1INCL = 0x00;
```

You can view our square wave in **Screenshot 7**.

SOURCES

Microchip
PIC16(L)F1507
HI-TECH C Compiler for PIC10/12/16 MCUs
PICkit3
MPLAB IDE
www.microchip.com

Digilent, Inc.
Electronics Explorer
www.digilentinc.com

WHEN YOU'RE DONE

The PIC16(L)F1507 is an extended midrange microcontroller. When you've finished exploring all of the ins and outs of the NCO and CLC, you can move on to the other PIC16(L)F1507 features and peripherals. Then, add the PIC16(L)F1507 to your Design Cycle. **NV**

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#43 SMILEY'S WORKSHOP

C PROGRAMMING - HARDWARE - PROJECTS

by Joe Pardue

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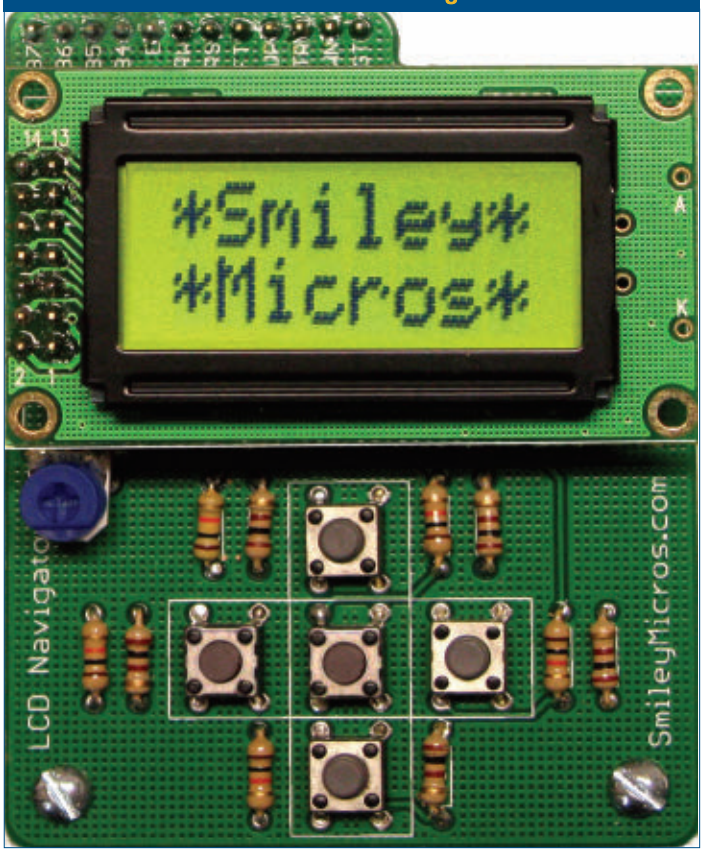
Breadboard LCD Navigator — Part 2: The Navigator Buttons

Recap

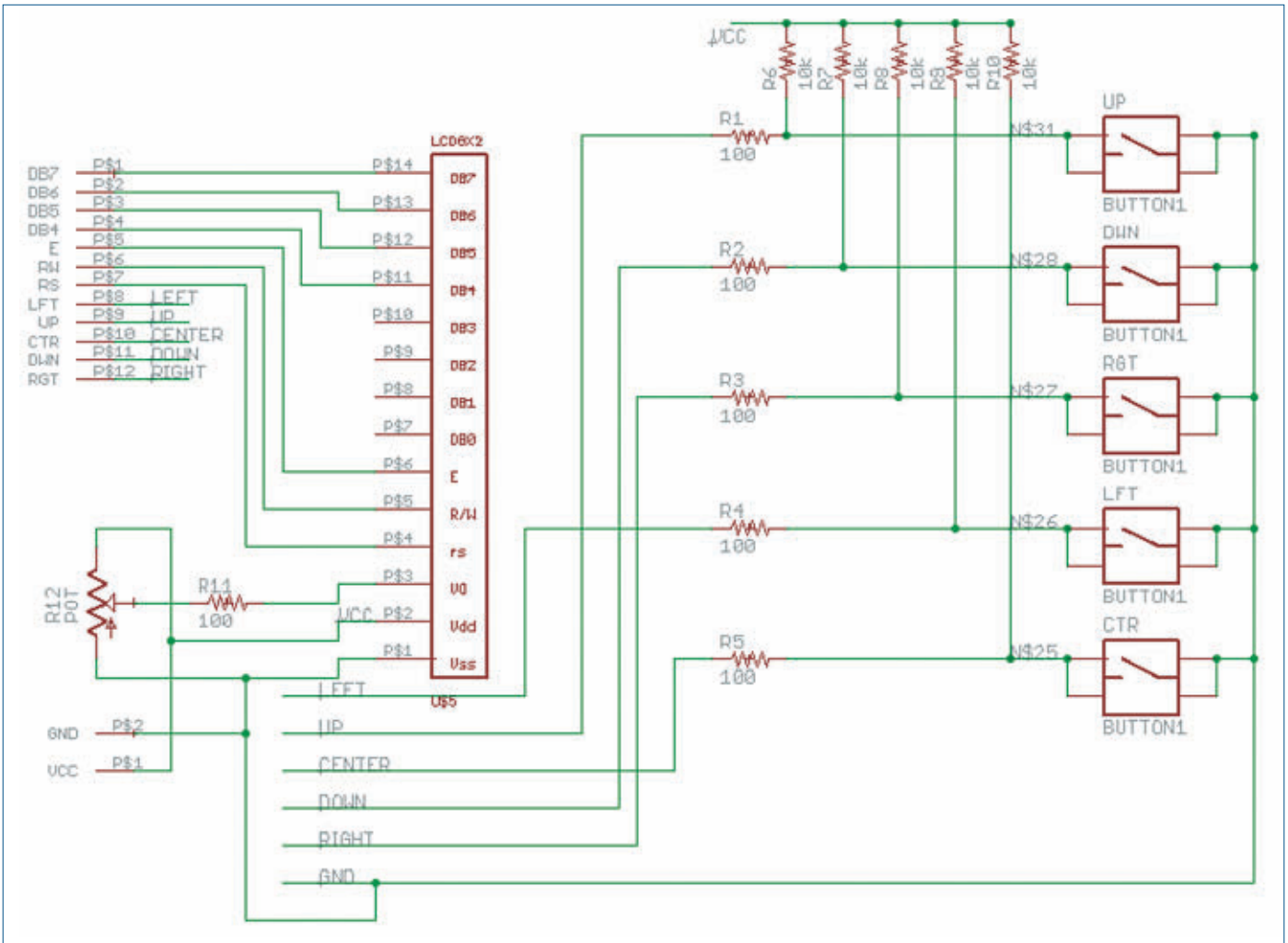
Last month, we looked at the LCD part of the LCD Navigator project. This month, we will look at the Navigator part: the five momentary pushbuttons arrayed as a cross in **Figure 1**. These buttons can be used to navigate a menu much like you would typically do with a TV remote control five-button navigator as shown in **Figure 2**. These buttons typically don't have labels since most folks intuitively know that they are up, down, left, right, and select after just a few moments of messing with them and watching what happens on a TV menu.

We will first look at the hardware considerations for using mechanical switches like these pushbuttons. Then, we will learn to use the nav_button library that you can find in avrtoolbox, buried fairly deeply in the folder tree at avrtoolbox\libavr\source\driver\external_hardware\nav_button. You can get this from the avrtoolbox repository at **http://code.google.com/p/avrtoolbox**. You will probably want to start with the tester library at avrtoolbox\libavr\testers\nav_buttons.

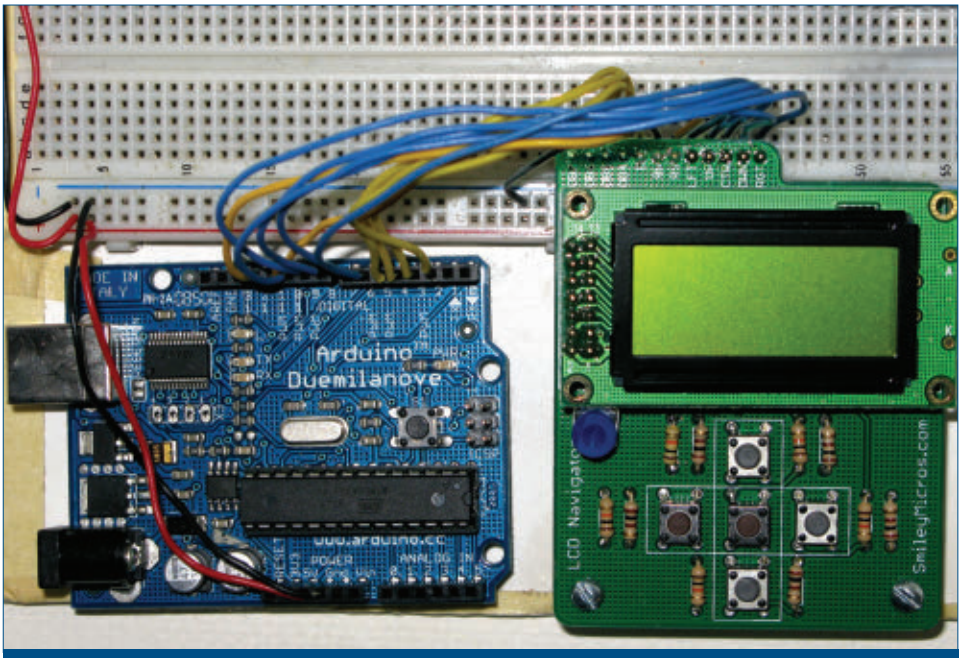
■ FIGURE 1. LCD Navigator.



■ FIGURE 2. Typical remote control menu navigation buttons.



■ FIGURE 3. LCDNAV schematic.



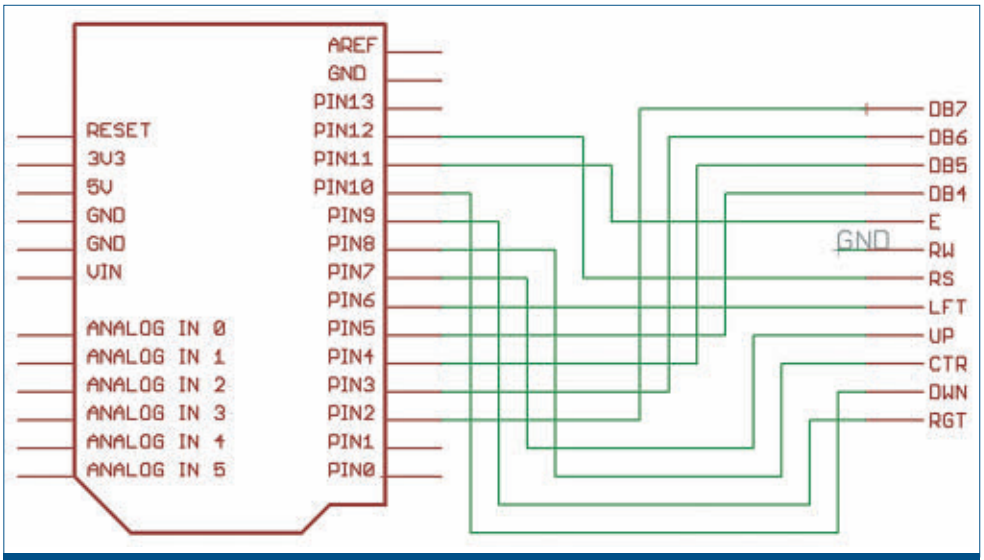
■ FIGURE 4. LCD Navigator with Arduino.

The LCD Navigator

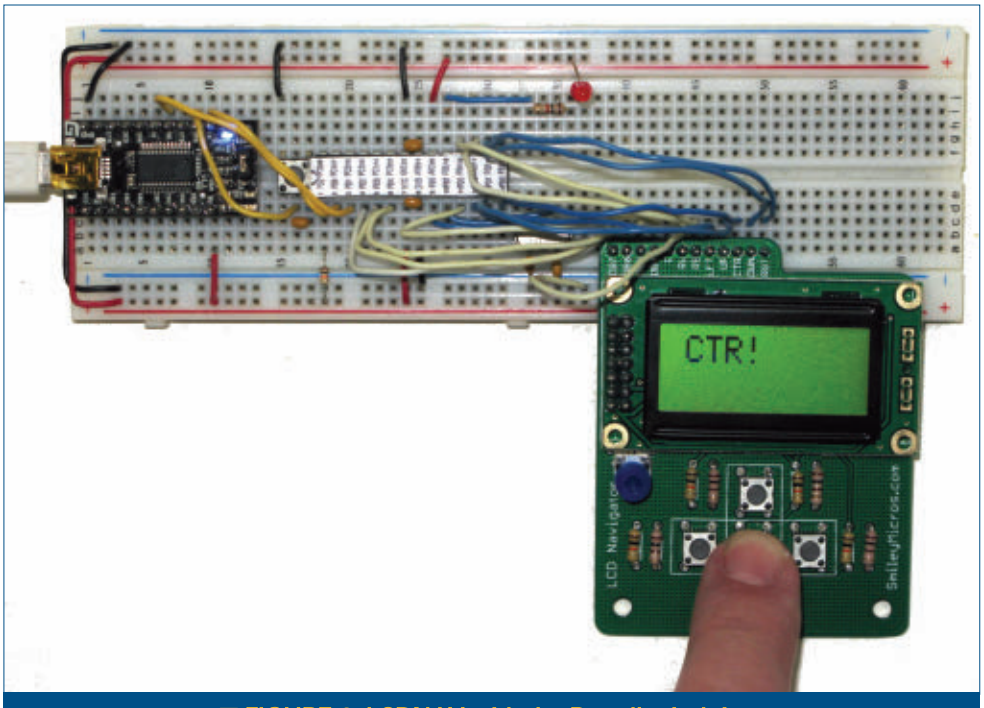
The LCD Navigator board schematic from last month's Workshop is shown in **Figure 3**; and a picture of it connected to an Arduino via a breadboard is shown in **Figure 4**. The breadboard wiring is shown in **Figure 5**. You may already have this wired up to test last month's LCD code. LCDNAV wiring to the Arduino is as follows:

- DB7 Pin 2
- DB6 Pin 3
- DB5 Pin 4
- DB4 Pin 5
- E Pin 11
- RW GND
- RS Pin 12
- LFT Pin 6
- UP Pin 7

■ FIGURE 7. ATmega328 port pin label.



■ FIGURE 5. LCDNAV wired to Arduino.



■ FIGURE 6. LCDNAV with the BreadboArduino.

- CTR Pin 8
- DWN Pin 10
- RGT Pin 9

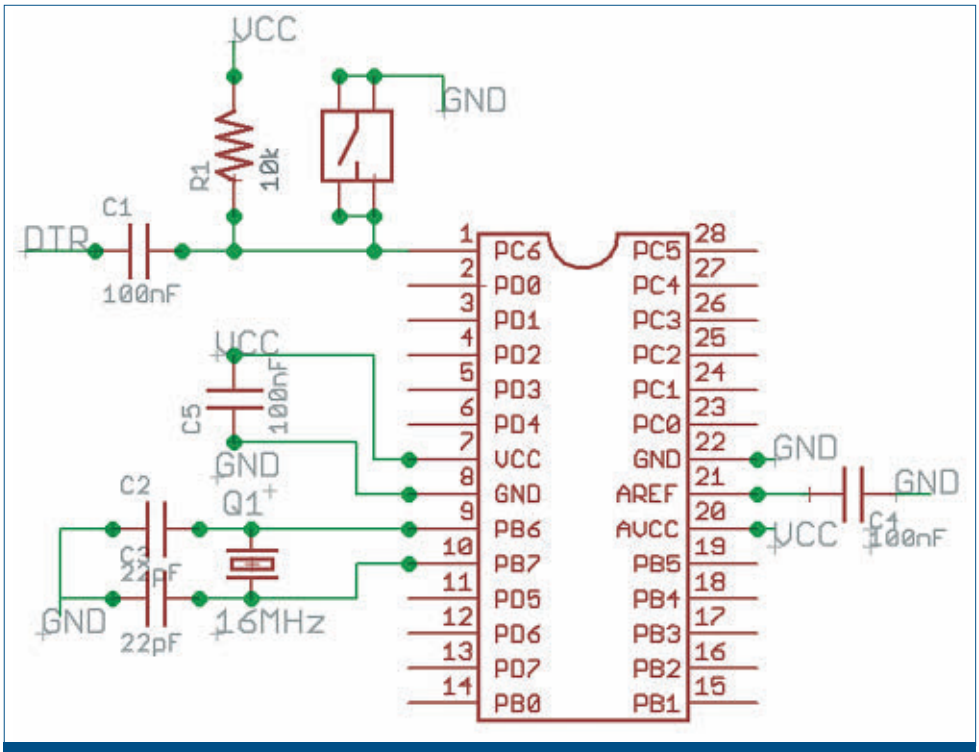
Navigator Buttons: Hardware

You can use this with the Arduino as shown in **Figures 3**, **4**, and **5** or you can use the BreadboArduino that we used in Workshop 41 (December '11). [You can purchase the BreadboArdino chaser lights project kit from the *Nuts & Volts* webstore.] Please keep in mind that even though we demonstrate the LCDNAV board using Arduino compatible hardware, we will use code that is regular C using the regular free AVR C tools: AVRStudio, WinAVR, and avrdude. (Please note that this was tested with AVRStudio 4, not the latest version 5 that according to the buzz on AVRFreaks is not ready for prime time.) To help wire this thing up, I've generated a label for the ATmega328p shown in both **Figures 6** and **7** that you can print out and put on the chip using double-sided sticky tape. You can get this in avrtoolbox at \testers\nav_buttons\atmega328_label.doc.

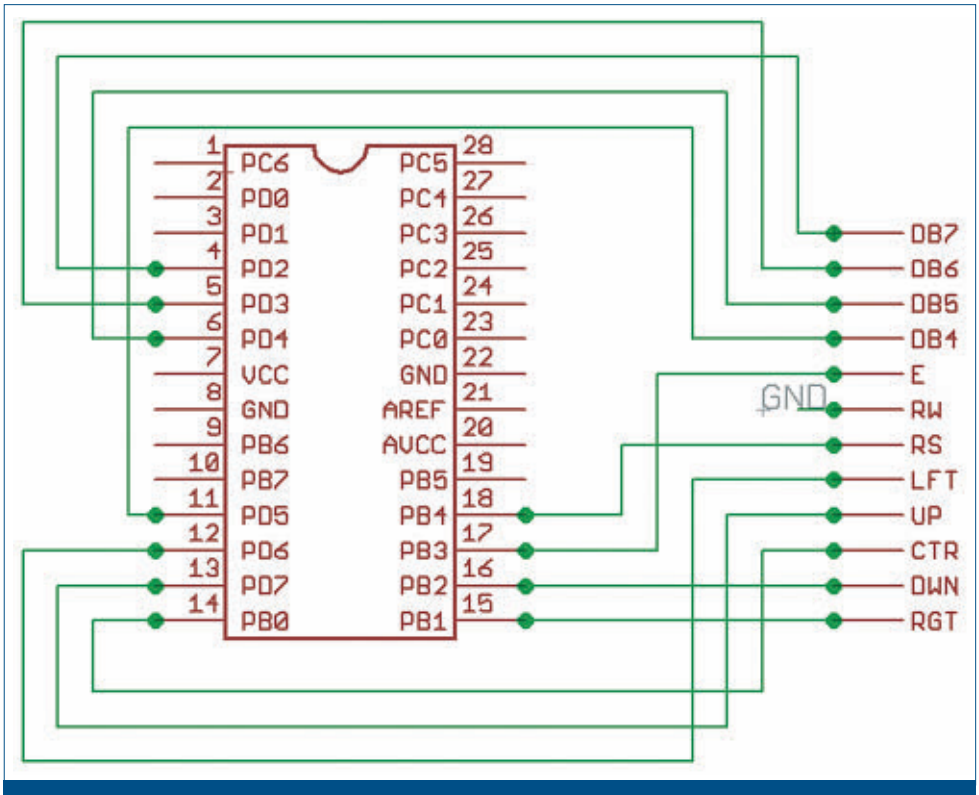
Wiring LCDNAV to the BreadboArduino

Now, get out the BreadboArduino chaser lights project that you did a few weeks back and pull off all those parts that were specific to the chaser lights. (Ouch! I know, but see the end of this Workshop for a PCB solution to your loss.) **Figure 8** shows the BreadboArduino schematic and **Figure 9** shows how you'll wire up the LCDNAV connections to the ATmega328p on the breadboard. You saw how this should look in **Figure 6**. Good luck! LCDNAV wiring to the ATmega328 on the BreadboArduino is as follows:

- DB7 Pin 4 (PD2)
- DB6 Pin 5 (PD3)
- DB5 Pin 6 (PD4)
- DB4 Pin 11 (PD5)



■ FIGURE 8. BreadboArduino basic wiring.



■ FIGURE 9. LCDNAV wired to BreadboArduino.

- E Pin 17 (PB3)
- RW GND
- RS Pin 18 (PB4)
- LFT Pin 12 (PD6)
- UP Pin 13 (PD7)
- CTR Pin 14 (PB0)
- DWN Pin 16 (PB2)
- RGT Pin 15 (PB1)

Navigator Buttons: Software

Whether you choose to build this project for an Arduino board or the BreadboArduino or any other AVR development board, you'll want to first test it with the nav_buttons tester software. When you run this code, the first message output is "NavButt." (I wasn't trying to be funny; it's just that with only eight characters and two lines we have to be parsimonious with our text.) This is followed shortly by the revision number, then the screen blanks and waits for you to press a button. **Figure 6** shows the message that is printed if you press the center button: CTR!

The program spins in a forever loop - for(;;) checking the nav_available() function to see if — well, can you guess? Right. It returns 0 if no button has been pressed and not 0 if a button has been pressed. The 'not 0' is a number that has a bit for each button press identified. We assume that there will generally only be one bit set but you might get several pressed at the same time, so the code processes the bits sequentially setting each bit back to 0 when it has been handled until all the bits are set back to 0. As you will see shortly, this sequential processing gives you the opportunity to prioritize the key presses so that, for instance, the CTR key will always be processed before any other key.

The Navigator Library

The Navigator library consists of nav.c and nav.h which exposes a few simple functions:

```
void nav_init(); // initialize the navigator
```

LISTING 1

```
#include
"c:\avrtoolbox\libavr\source\general\util\util.
h"
#include
"c:\avrtoolbox\libavr\source\driver\external_
hardware\
lcd_hd44780\lcd.h"
#include
"c:\avrtoolbox\libavr\source\driver\external_
hardware\
nav_button\nav.h"

int main( void )
{
        uint8_t key = 0;

        lcd_init();
        nav_init();

        lcd_puts("NavButt");
        delay(500);
        lcd_clear();
        lcd_puts("REV028");
        delay(1000);
        lcd_clear();


   for(;;)
   {
        if(nav_available())
        {
                key = nav_get_key();

                if(key == CTR)
                {
                        lcd_home();
                        lcd_blank(16);
                        lcd_puts("CTR!");
                }
                if(key == LFT)
                {
                        lcd_home();
                        lcd_blank(16);
                        lcd_puts("LFT!");
                }
                if(key == RGT)
                {
                        lcd_home();
                        lcd_blank(16);
                        lcd_puts("RGT!");
                }
                if(key == UP)
                {
                        lcd_home();
                        lcd_blank(16);
                        lcd_puts("UP!");
                }
                if(key == DWN)
                {
                        lcd_home();
                        lcd_blank(16);
                        lcd_puts("DWN!");
                }
                delay(100);
                lcd_home();
                lcd_blank(16);
        }
   }
}
```

```
buttons
uint8_t nav_available(); // true if a new button
press is available
uint8_t nav_get_button(); // return the next
available button
```

Listing 1 makes for a very simple tester program. When we press the down button, the LCD shows DWN! as shown in **Figure 10**.

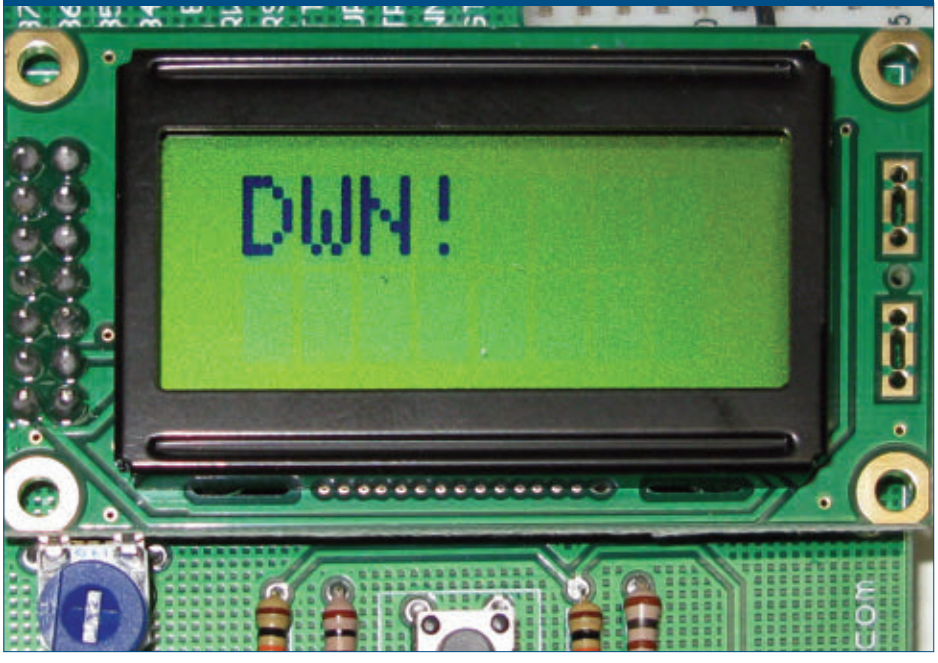
As usual, this simplicity is hiding some complexity under the hood that we will look at in more detail. When you first look at this — especially if you are a novice — you might correctly ask 'Where is all the code that notes when a button is pressed?' Well, that is all set up by the nav_init() routine that sets up an ISR (Interrupt Service Routine) that runs in the background, out of sight of our main loop. A timer peripheral is set to interrupt the main code every 5 mS (milli-seconds or 0.005 seconds) and check the state of the buttons. If a button is low for five consecutive 5 mS intervals (25 mS), then we are reasonably sure that the button has been pressed. We will get into a lot of detail about timers and ISRs in another Workshop, but for now I recommend that you look at the nav_init() function to get a feel for what is going on.

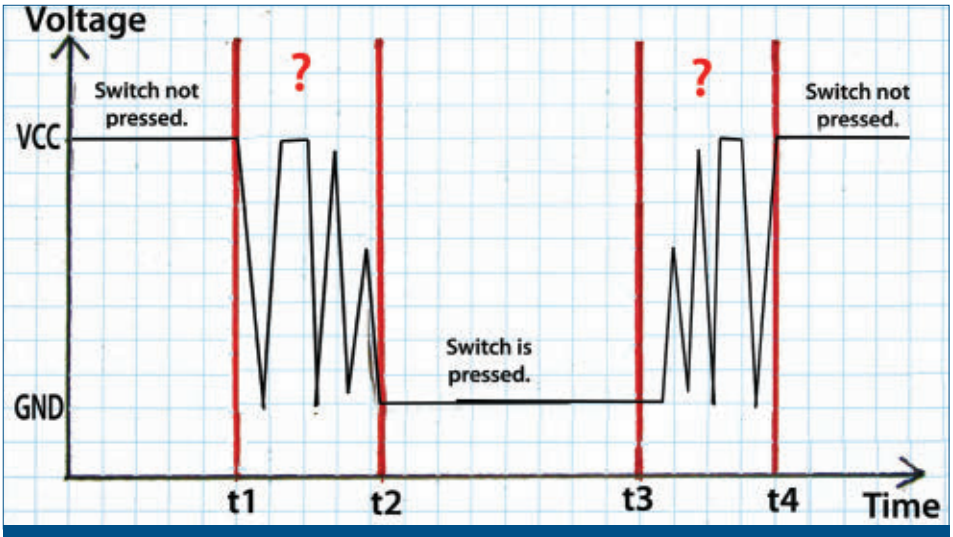
There are several other neat tricks hidden under the hood of this code, including the way the port pins are mapped to each of the five buttons. For example:

```
#define NAV_LFT_PORTX PORTD
#define NAV_LFT_DDR DDRD
#define NAV_LFT_PINX PIND
#define NAV_LFT_PIN PD6
```

Here we see that we require four separate definitions just for setting up the LFT button in the initiation. If you want to wire the buttons to different ports and pins, you will need to change them in these definitions in nav.h.

■ FIGURE 10. DWN!





■ FIGURE 11. Switch bounce.

If you look a little deeper at the code in nav.c, you'll see a rather bizarre-seeming algorithm for accepting a button push as valid. Before looking at that code, we'll need to take a moment to examine the topic of switch bounce and the debouncing thereof.

Switch Bounce

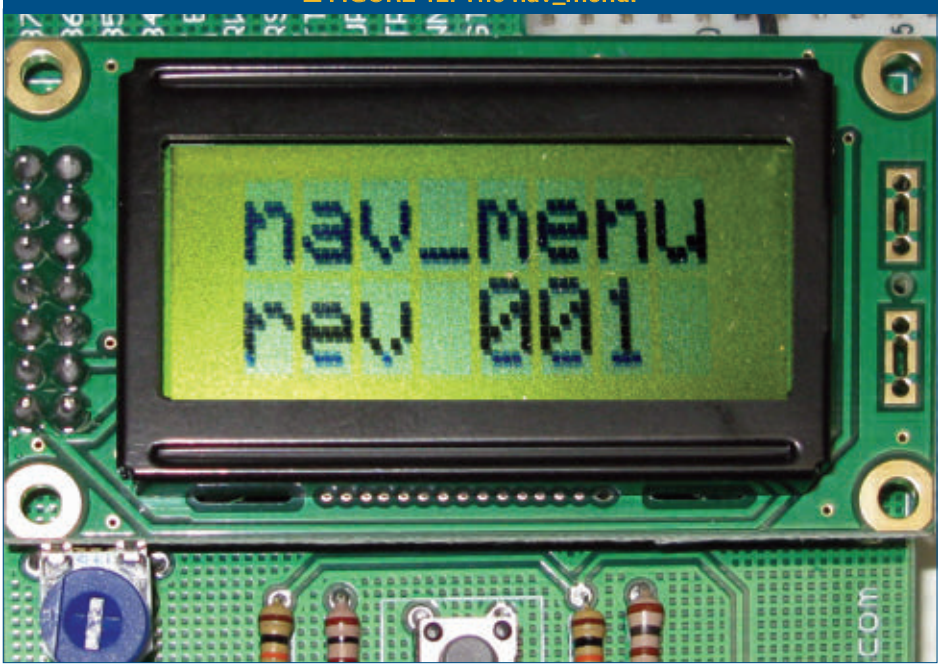
Each of the Navigator buttons is connected to a 10K Ω pull-up resistor to VCC and a 100 Ω current-limiting resistor to the breadboard pin as shown in **Figure 3**. When the button is not pressed, the breadboard pin is pulled up to VCC and reads as a 1 if the associated AVR pin is set to digital input. When the button is pressed, the breadboard pin is connected to ground (through the current limiting 100 ohm resistor) and the AVR digital input reads 0. Well, this is going to be easy. We only have to look for a 0 or a 1, right? Wrong! In the button, the actual mechanical connection is not instantaneous and, in fact, the voltages bounce around and take a bit of time from a computer perspective to settle on either VCC or GND, which leads to the button being in output bouncing between 1 and 0 like crazy. **Figure 11** illustrates what happens to the voltage across a switch as it is pressed and released.

Jack Ganssle provides an excellent discussion of switch bounce at **www.ganssle.com/debouncing.htm**.

The algorithm I use in nav.c to deal with switch bounce is fairly clear and teachable, but not any where near the most efficient that can be used. As usual, I came up with what I thought was a good algorithm for dealing with this, only to find out on **AVRFreaks.net** (**http://tinyurl.com/6hjz5yt**) that others have been down this path before me and done a better job. I will admit that the 'best' way of doing this is very dense and not easy to understand, so for now let's just use our less efficient technique and save the more efficient (and harder to understand) version for a later Workshop.

Some of the more perceptive readers will want to know why we have to use the 10K ohm resistor to pull up the switch when we can configure the pull-up resistors for the input pins. They may also want to know why we need the 100 ohm resistor at all. The answer is that this design is for novices using a breadboard and neither resistor would be needed if we could be sure that all users would use this thing properly. The 100 ohm resistor is there for the person who accidentally configures the button pin to output and then sets it high, thus providing a direct path from VCC to GND if the 100 ohm resistor wasn't there to prevent it. The 10K ohm resistor is for the person who configures the pin to input and then sets it to 0, which would provide a direct path from VCC to GND.

■ FIGURE 12. The nav_menu.



Simple Menu Navigation Software

Unlike many of the software projects we encounter, menu software doesn't lend itself to a generic library. Instead, it involves learning about and creating state machines that can vary in complexity

from very complex to extremely complex. We'll try to keep it as simple as we can and only use the C switch statement that we've seen before as our state machine in a simple demonstration application nav_menu.c that you can find under the avr_applications section of avrtoolbox. You can use it as a template if you want to write a menu system of your own. In this application, we will also show how to enter text and numbers using the Navigator keys.

The nav_menu.c application builds on the tester code shown above using a series of switch statements in functions to keep track of the system state. The program opens with the LCD showing the program name and revision as shown in **Figure 12**.

First, we define the number of states: #define MAX_TOP 5 — and don't forget that since we are counting from 0, that the maximum of five means that we actually will have six functions named according to what they do as follows:

```
Enter text
Enter number
View text
View number
Erase text
Erase number
```

When we run the code, the forever loop will either increment or decrement a variable 'top,' depending on our presses of the UP or DWN key:

```
if(key == UP)
{
        if (top <= MAX_TOP) top++;
}

if(key == DWN)
{
        if (top > 0) top—;
}
```

At the end of the loop, we wait half a second to make sure the user has pressed and released a key, then we show the 'top' number on the second line of the LCD:

```
delay(500);
lcd_set_cursor( 0, 1 );
lcd_puts(itoa(top,num,10) );
```

When the user pressed the center (CTR) button:

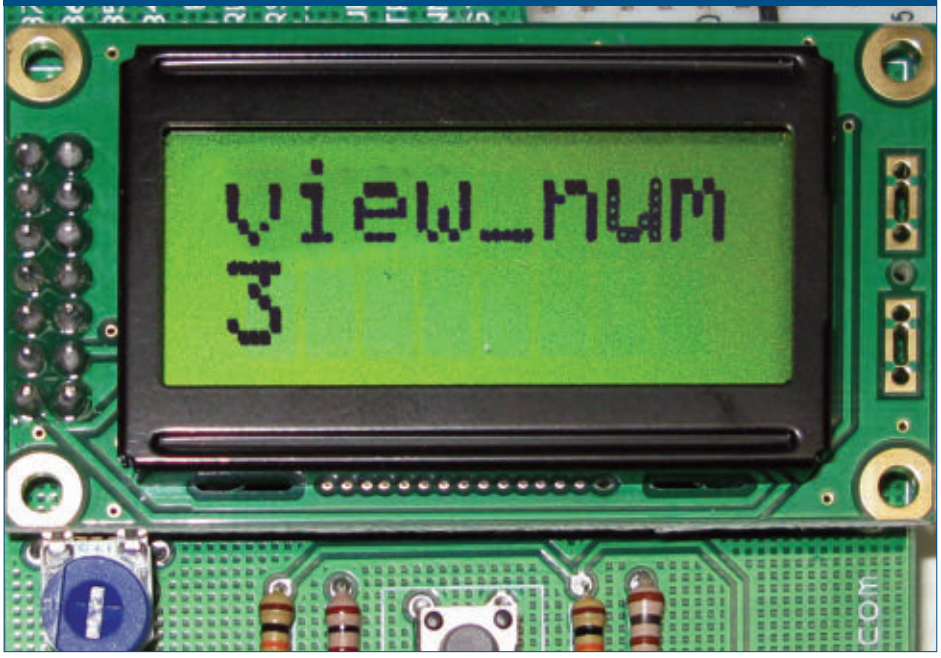
```
if(key == CTR)
{
        get_top(top);
}
```

The get_top(top) function is called:

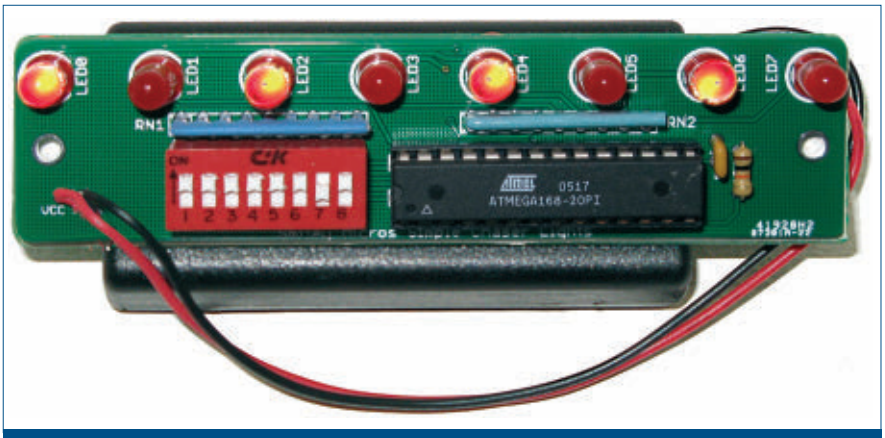
```
void get_top(uint8_t get)
{
        switch (get)
        {
                case 0:
                        entr_txt();
                        break;
                case 1:
                        entr_num();
                        break;
                case 2:
                        view_txt();
                        break;
                case 3:
                        view_num();
                        break;
                case 4:
                        erse_txt();
                        break;
                case 5:
                        erse_num();
                        break;
                default:
                        break;
        }
}
```

Suppose you press the up button four times to show the number 3, and then press CTR. This will switch to case 3 which calls the view_num() function:

■ FIGURE 13. The view_num.



Theory is all well and good, but to really learn this stuff you have to get your hands on some tangible items that blink, whirr, and sometimes detonate. As a service for the readers of the Smiley's Workshop articles, we have simple and inexpensive projects kits available that can help you make it real. You can find these kits (and some darn good books) at the *Nuts & Volts* Webstore.



■ FIGURE 14. Chaser lights board.

```
//View number
void view_num()
{
    lcd_clear();
    lcd_puts_p(view_num_txt);
}
```

The view_num_txt was defined as some text in PROGMEM space as follows:

```
const char view_num_txt[] PROGMEM =  "view_num";
```

The LCD displays the called function name on line one along with the number for that state on line two, as shown in **Figure 13**.

The functions that let you enter text and numbers are interesting, but a bit much for this month's Workshop so we'll just let you look at the source code if you are interested.

Preview: Simple Chaser Lights Board

If you purchased the BreadboArduino kit and constructed the simple chaser lights project last month, you are probably going to think that it is such a shame to tear up that project just to get at the BreadboArduino so that we can test our LCDNAV. If only there was something we could do to have all those blinking lights AND test the LCDNAV board ... Well, **Figure 14** shows that we now have an alternative to building the chaser lights on a breadboard; we can get a printed circuit board and parts kit from *Nuts & Volts* that lets you build a permanent platform for your chaser lights experiments.

The main difference between this board and the circuit discussed in Workshop 41 is that this one does not have a communication channel for reprogramming. It comes preprogrammed with most of the light patterns discussed before and, as a bonus, it has some POV (Point Of View) messages that allow you to write text in the air by waving the board like a wand as we'll learn all about in next month's Workshop. You will find the simple_chaser_lights and the pov_wand software in avrtoolbox under the avr_applications directory, so you can get a head start on this visually-arresting project before we look at the details next month.

Questions? *Nuts & Volts* is hosting forums for its writers and you can find mine at **http://forum.servomagazine.com**. If you want a really quick response — especially to a question not directly related to an article — you could put on your biohazard suit and start a thread on **www.avrfreaks.net**.

If you just can't wait and want to get a leg up on all this serial stuff and real C programming for the AVR (while helping support your favorite magazine and technical writer), then buy my *C Programming* book and Butterfly projects kit and the *Virtual Serial Port Cookbook* at the *Nuts & Volts* webstore. **NV**

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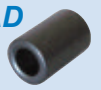

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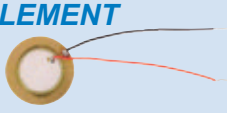

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■ BY LOUIS E. FRENZEL W5LEF

COMM KITS

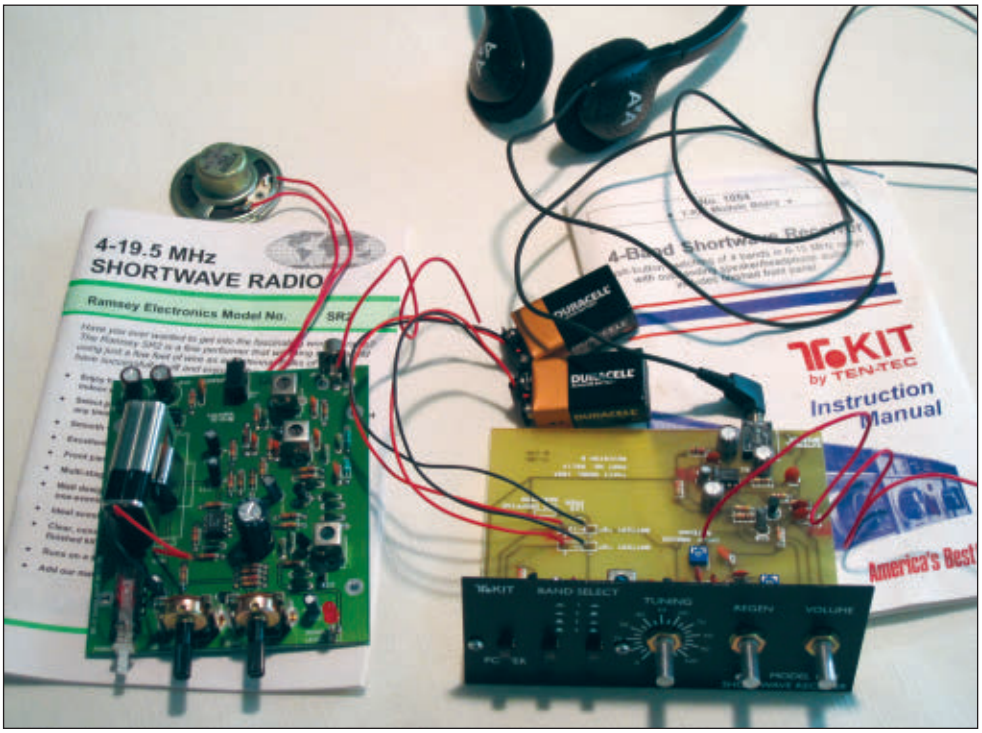
A radio kit is a great way to get familiar with electronics and communications.

When is the last time you built a kit? Or, have you ever built a kit? A kit is a super way to get close to electronics, and building a communications kit like a radio is more interesting and useful than other electronic devices. I have built many kits over the years and a high percentage of them have been radios. If you are looking for a way to explore electronics or to experiment with radio-related technology, kits are the way to go. Here is a look at some available comm kits and some tips on kit building in general.

SWL RADIOS

A great way to start with kit building is to make a shortwave receiver. They are relatively easy to build and shortwave listening is pretty interesting because of the variety of stations out there. There are two SWL radios I can recommend. One of these is the Ramsey Electronics SR-2C (see **Figure 1**). It is an actual superheterodyne radio with input filter, mixer, IF amplifier with AGC, and an audio power amplifier output. The tuning range is 4 to 20 MHz which covers most of the really interesting shortwave broadcasts. Tuning is done with a pot that varies the DC bias voltage on a varactor diode. A varactor is really a voltage variable capacitor that varies the local oscillator frequency. That range is limited to a few MHz, and the kit gives you the option to select some capacitor values and coil adjustments that will give you the range you want. I selected the 6 to 11 MHz range that has lots of stations, as well as WWV's 10 MHz time signal.

The kit itself is a single printed circuit board (PCB) and all through-hole components. No surface-mount parts. It is very easy to build. It only took me a few hours, but if this is your first



■ FIGURE 1. On the left is the Ramsey SR-2C shortwave radio. On the right is the Ten-Tec 1054 radio. Both are easy to build and do a great job on the primary shortwave bands.

kit, you may take longer. In any case, take your time (see the **sidebar** *Kit Building Tips*). The construction manual is very clear and there are enough diagrams to help you out in critical places.

The audio amplifier has enough power to drive a small speaker, but the volume is not great. It is better to use a set of earphones for volume and listening comfort. The radio operates from a single nine volt battery.

Let's get this out straight away. You will definitely need an antenna for all these kit radios. Don't let this hold you back! Ramsey recommends an outside wire at least 25 to 50 feet long, or longer. I ended up using about 15 feet of #22 hook-up wire stretched out along the floor and got great reception. I keep wondering how much better reception would be with that outside antenna. The shortwave stations are plentiful.

Ramsey also sells a nice plastic enclosure for the radio. It finishes it off nicely. The kit currently sells for $44.95.

Another shortwave kit I built is the model 1054 from ham equipment manufacturer Ten-Tec (see **Figure 1**). This simple radio is of the regenerative type. It uses an amplifier with feedback (regeneration) to put the circuit into a near oscillating state. This greatly boosts amplifier gain and makes it highly sensitive to weak signals. It also narrows the bandwidth of the receiver making it more selective, making it easier to separate closely adjacent stations.

The tuning range is from 5.9 to 16.5 MHz — again, the sweet spot for most shortwave listening. This kit has two pushbutton switches that let you select four different bands within that range. Continuous tuning within each range is by way of a pot varying the bias on a varactor diode.

I have always been skeptical of regenerative receivers. They are simple but can be ornery. This one is not. It has a very controlled and smooth regeneration control. Along with the frequency tuning, you can easily pick out stations and optimize their reception.

The kit was easy to build. I did it in a few hours with no errors. It also uses an IC audio power amplifier in the output but again, headphones are your best bet for reception.

What I said earlier about an antenna applies here, as well. A long wire outside is recommended, but I used my 15 foot piece of hookup wire again with amazing results. My only gripe about this kit is that it needs two nine volt batteries. Performance is excellent and I can recommend it without reservation. The kit is available from Ten-Tec for $39.

There are several other shortwave kits on the market. I haven't tried them all but if you're looking for a more advanced SWL radio, take a look at MFJ Enterprises MFJ-8100K. It covers the 3.5 to 22 MHz range which includes most of the popular ham bands, as well. The price is $79.95.

If you want something other than shortwave, a good choice is the VHF bands that are loaded with stations to

KIT BUILDING TIPS

1. Choose a simple kit to start with if you have never built a kit or if it has been a while since you soldered something. A power supply is always a good first kit project since you can use it with many other projects.

2. Be sure you have the right tools. You will need a small soldering iron in the 20 to 35 watt range with a small tip. Use only rosin core solder of the 60/40 or 63/37 tin/lead mix. You will need small side cutters, needlenose pliers, a wire stripper, and a knife. A couple of small screwdrivers are also useful in some kits. I have found that a good bench light and magnifying glass are useful, as well. Your local RadioShack should have all you need.

3. When you start, check to see if you have all the parts. Check the components against the parts list. This is a pain to do, but it does two things for you. First, it makes you identify and recognize all of the components. Second, you will discover any missing parts so you can contact the kit company for replacements.

4. Scan through the instructions to see what is in store. Then begin.

5. Follow directions. Read them twice. Then, DO WHAT IT SAYS, NOT WHAT YOU WANT OR THINK IS CORRECT.

6. Go slow. We are all anxious to finish and use a kit, but be patient. If you mess up, it will kill the project altogether or introduce delays. It may also discourage you from building more kits. Most kit companies do not provide help and in most cases none is necessary if you follow the instructions correctly.

7. Be especially cautious when installing the parts. Read the resistor color code carefully. Watch for polarity markings on electrolytic capacitors and diodes. Putting these in backwards almost always results in damage to the part itself and/or damage to other parts. Also watch for the orientation of integrated circuits. If you put one in backwards, you may damage it when you try to remove it.

8. Use a light touch when soldering. Do not overheat PCBs or components. Use only enough heat to melt the solder. Go light on the solder. Too much solder can short out the PCB pattern or components.

9. If you do not know how to solder, get one of the several solder practice kits available. I recommend the Elenco Electronics AK100 — a neat electronic siren with flashing LEDs. It includes a soldering iron, all for $17.95. They have an easy to build AM/FM radio kit as well called the AMFM108K for $36.50. Both are highly recommended for beginners.

KIT COMPANIES

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Jameco
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MFJ
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Ramsey
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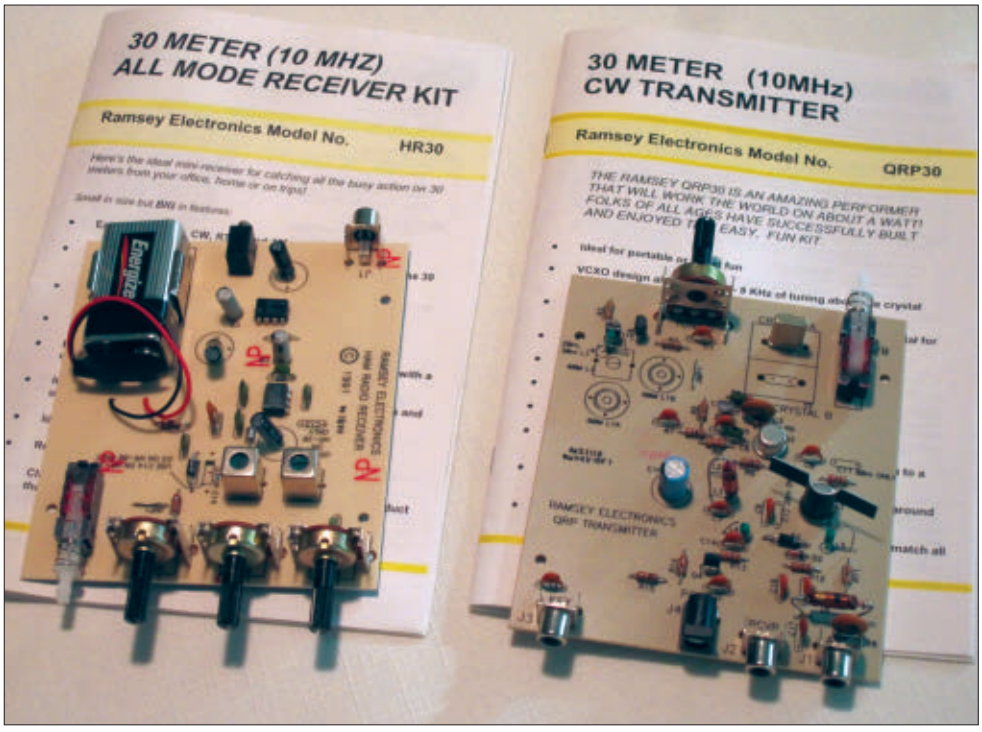


■ FIGURE 2. The Ramsey 30 meter ham radio kit. The SR30 receiver is on the left and the QRP30 is on the right. Both 20 and 40 meter versions are available.

explore. Some of the sources are aircraft, marine, public safety (police, fire, etc.), FM radio, and amateur radio. Some good kits for VHF are also from Ramsey. They have an aircraft radio (AR1C), an FM radio (FR1C), and several ham radio band kits. These are all superheterodyne FM radios except for the aircraft radio which is AM. They sell for $49.95. A flexible version is the FR146C. It is targeted at the two meter ham band but you can actually set it to any frequency in the 130 to 180 MHz range. The one I built I set to my local weather radio station in the 162 MHz band. All have optional cases to finish them off.

HAM RADIO KITS

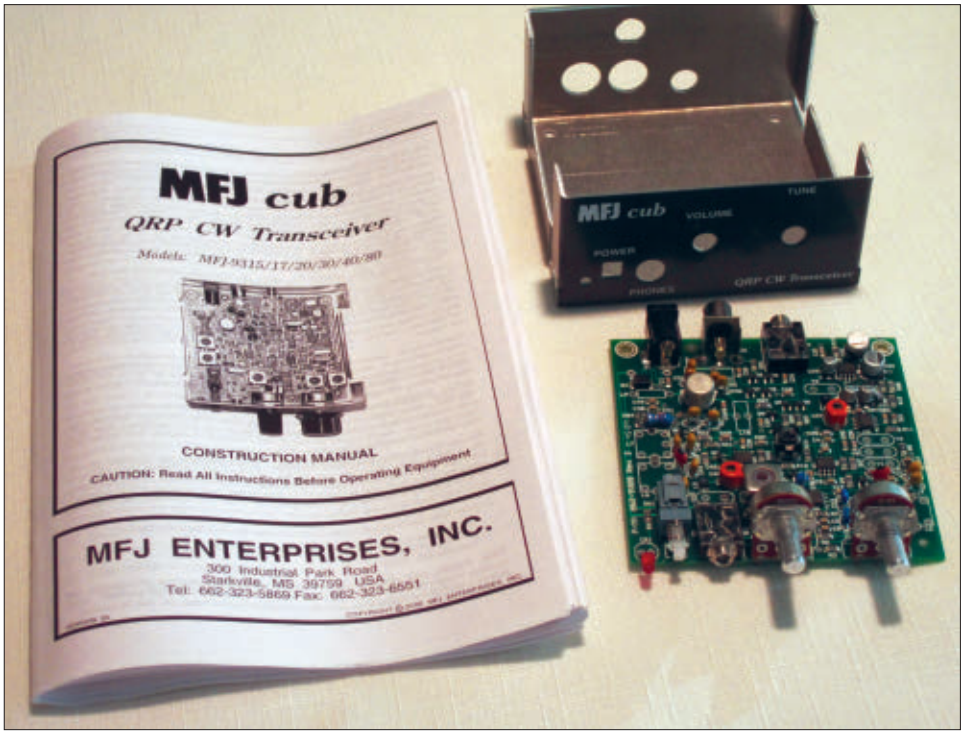
I have built several kit transmitters and receivers for the ham bands. Another recent example from Ramsey is their single band receiver and transmitter kits. I had never worked the 10 MHz 30 meter ham band and thought these kits would be a good introduction. I first built the SR30 receiver (see **Figure 2**). It is a direct conversion type that uses a mixer to down-convert the input signal directly to audio.

This one uses the popular NE602 mixer/oscillator IC. The antenna signal is passed through a tuned circuit at 10 MHz to the mixer. The mixer combines the input signal, with the internal oscillator signal also set to 10 MHz. Tuning is with a pot varying the bias on a varactor diode. The difference signal is then filtered and fed to an IC audio power amplifier. The output is sufficient for headphones only.

The kit was quick and easy to build but did require a bit of tinkering to tune it properly. It should have a proper 30 meter antenna. I built a 46 foot dipole fed with RG-58/U coax that worked great. The unit operates from a single nine volt battery.

Another ham receiver kit is the Ten-Tec 1056. Like the Ramsey radio, it is a direct conversion type using an NE612AN IC mixer/oscillator. The unit will operate on any of the ham bands at 160, 80, 40, 30, 17, 15, or 10 meters. Parts are supplied for all these bands, but you have to decide which one you want when you build it. I have not put this one together yet, but it is an option for you. Price is only $32.

I also built the Ramsey QRP30



■ FIGURE 3. The MFJ-9340 Cub transceiver. It's very small and comes with surface-mount parts already installed. Still a bear to build.

30 meter transmitter (refer to **Figure 2**). It is a QRP (<5 watts of power) transmitter whose output is in the one to three watt range. It uses a 2N3904 oscillator with two 10 MHz crystals that can be "pulled" or tuned over the 30 meter band range with a pair of varactor diodes. Two 2N3053 transistors are used as a buffer and final power amplifier.

The transmitter needs a 12 to 15 volt power supply that can provide up to 300 mA. You will need to buy such a supply or build one from a kit. I built a power supply kit from Jameco. This is the 20626 — a dual adjustable power supply with a range from 1.2 to 15 volts, and a current capability up to 750 mA. You can also use a string of eight or 10 D cells to get 12 or 15 volts. The transmitter feeds into the antenna through a low pass filter to get rid of the harmonics generated by the class C power amplifier. A built-in diode antenna switch lets you use the same antenna for both receive and transmit.

Ramsey also makes a power amplifier for the transmitter. Called the QAMP30, this amplifier uses a pair of MOSFETs in push/pull to deliver up to 20 watts output. I have the kit but have not built it yet. The low power of the base transmitter seems adequate for most operations.

Incidentally, the Ramsey kits are available for the 40 and 20 meter bands, as well as 30 meters. The basic receiver sells for $44.95. The transmitters are also available for 40 and 20 meters. They sell for $49.95. The power amplifiers go for $44.95. Overall, these kits are a really cheap way to get into ham radio.

My latest project is the MFJ Enterprises Cub QRP CW transceiver, designated as the MFJ-9340. It is a complete 40 meter transmitter and receiver in a small package. The receiver uses a very selective 12 MHz crystal IF filter and the transmitter puts out up to two watts. It sells for $99.95 (see **Figure 3**). The transceiver uses surface-mount parts but these are already pre-installed. Other through-hole PCB parts that are somewhat easy to install are used in the rest of the kit.

I haven't finished building the kit yet because I already screwed it up by misidentifying some of the components. I have built dozens of kits over the years and rarely mess up, but I mistook some inductors for capacitors and in trying to remove these parts I damaged the PCB. I am now waiting for some new parts, and hope and pray that I can fix the board. The small size of the unit has made component access tough. My warning to you is: Go ahead and build a kit but just be extra careful in IDing the parts and installing them. TAKE YOUR TIME!!

I have to say that this is not a beginner's kit. Stick to larger kits with more widespread parts to begin with. Then after you are comfortable with soldering and parts identification, you can take a chance on a more sophisticated kit. **NV**

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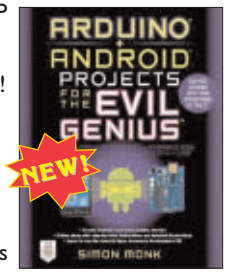

TEAM ARDUINO UP WITH ANDROID FOR SOME MISCHIEVOUS FUN! This wickedly inventive guide covers the Android Open Application Development Kit (ADK) and USB interface, and explains how to use them with the basic Arduino platform. Methods of communication between Android and Arduino that don't require the ADK — including sound, Bluetooth, and WiFi/Ethernet — are also discussed. An Arduino ADK programming tutorial helps you get started right away.

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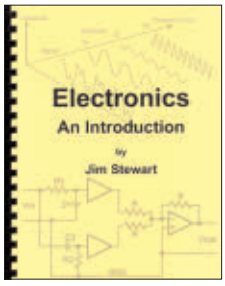
by Jim Stewart



This book is designed as an in-depth introduction to important concepts in electronics. While electronics can be highly mathematical, this text is not about calculations. It is about how electronic equipment is able to extract, process, and present information held in electrical signals. If you are in — or studying to be in — a profession that requires the use of electronic equipment, then this book will provide the insight necessary to use such equipment effectively.

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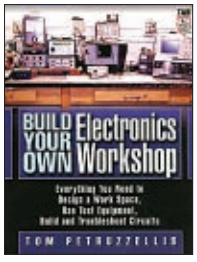
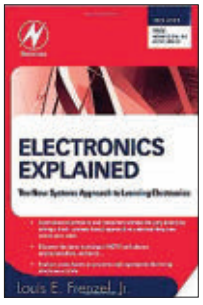


This value-packed resource provides everything needed to put together a fully functioning home electronics workshop! From finding space to stocking it with components to putting the shop into action — building, testing, and troubleshooting systems. This great book has it all! And the best part is, it shows you how to build many pieces of equipment yourself and save money, big time!

Reg Price $29.95
Sale Price $26.95

Electronics Explained
by Louis Frenzel

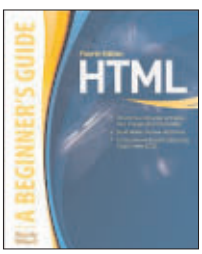
The New Systems Approach to Learning Electronics



Don't spend time reading about theory, components, and old ham radios — that's history! Industry veteran, Louis Frenzel, gives you the real scoop on electronic product fundamentals as they are today. Rather than tearing electronics apart and looking at every little piece, the author takes a systems-level view. For example, you will not learn how to make a circuit but how a signal flows from one integrated circuit (IC) to the next, and so on to the ultimate goal.

$39.95

HTML: A Beginner's Guide
by Wendy Willard



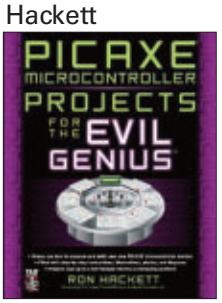
Create highly functional, impressive websites in no time. Fully updated and revised, *HTML: A Beginner's Guide*, Fourth Edition explains how to structure a page, place images, format text, create links, add color, work with multimedia, and use forms. You'll also go beyond the basics and learn how to save your own web graphics, use Cascading Style Sheets (CSS), create dynamic web content with basic JavaScript, and upload your site to the web. By the end of the book, you'll be able to build custom websites using the latest HTML techniques.

$29.95

Programming PICs in Basic
by Chuck Hellebuyck

If you wanted to learn how to program microcontrollers, then you've found the right book! Microchip PIC microcontrollers are being designed into electronics throughout the world and none is more popular than the eight-pin version. Now the home hobbyist can create projects with these little microcontrollers using a low cost development tool called the CHIPAXE system and the Basic software language. Chuck Hellebuyck introduces how to use this development setup to build useful projects with an eight-pin PIC12F683 microcontroller. **$14.95**

PICAXE Microcontroller Projects for the Evil Genius
by Ron Hackett



This wickedly inventive guide shows you how to program, build, and debug a variety of PICAXE microcontroller projects. *PICAXE Microcontroller Projects for the Evil Genius* gets you started with programming and I/O interfacing right away, and then shows you how to develop a master processor circuit.

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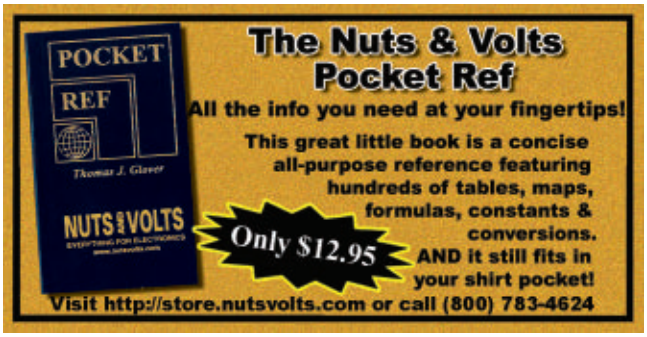
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PROJECTS

Transistor Clock Kit

If you like electronic puzzles, then this kit is for you! There are no integrated circuits; all functionality is achieved using discrete transistor-diode logic. The PCB is 10"x11" and harbors more than 1,250 components! For more info, see the November 2009 issue.

Reg $225.95
Sale Price $199.95
PCBs can be bought separately.

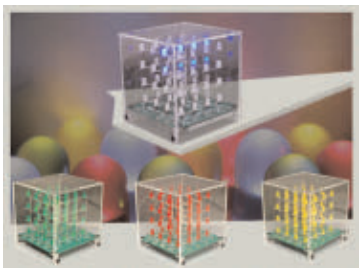
Battery Marvel Kit

As seen in the November 2011 issue. Battery Marvel helps protect cars, trucks, motorcycles, boats, and any other 12V vehicles from sudden battery failure. This easy-to-build kit features a single LED that glows green, yellow, or red, indicating battery health at a glance. An extra-loud piezo driver alerts you to any problems.

For more info, please visit our website.

Subscriber's Price **$18.95**
Non-Subscriber's Price **$19.95**

3D LED Cube Kit



This kit shows you how to build a really cool 3D cube with a 4 x 4 x 4 monochromatic LED matrix which has a total of 64 LEDs. The preprogrammed microcontroller that includes 29 patterns that will automatically play with a runtime of approximately 6-1/2 minutes.
Colors available: Green, Red, Yellow & Blue

Subscriber's Price **$57.95**
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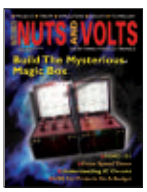
Magic Box Kit



As seen on the April 2007 cover.

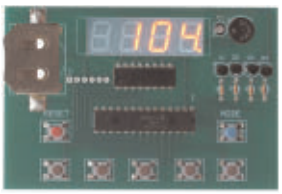
This unique DIY construction project blends electronics technology with carefully planned handcraftsmanship. This clever trick has the observer remove one of six pawns while you are out of the room and upon re-entering you indicate the missing pawn without ever opening the box.

Includes an article reprint.

Subscriber's Price **$39.95**
Non-Subscriber's Price **$45.95**

Sorting Counter Kit

As seen in the July 2011 issue.

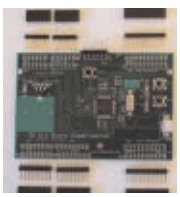


Sorting counters have many uses — keeping score, counting parts, counting people — it is just a handy gadget to have around. This is a very simple project for those who want to learn to solder or are interested in using microprocessors and how they function. No special tools are needed, just a small tip soldering iron. It has no box as it stands alone, therefore there is no drilling.

Subscriber's Price **$33.95**
Non-Subscriber's Price **$39.95**

32-Bit Micro Experimenter Board

The 32-Bit Micro Experimenter is the fastest way to learn 32-bit microcontrollers.



The kit includes onboard 46 programmable I/O and USB, free software, carefully documented step-by-step experiments for USB, embedded web server, graphics and audio, wireless, RTOS, and file I/O. User pushbuttons, LEDs, and 32 kHz clock crystal. Can be used in solderless breadboard environment or stand-alone.

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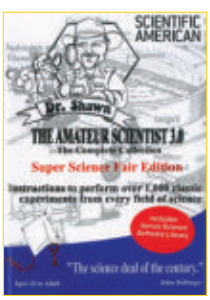
The Amateur Scientist 4.0 The Complete Collection

by Bright Science, LLC



There are 1,000 projects on this **CD**, not to mention the additional technical info and bonus features. It doesn't matter if you're a complete novice looking to do their first science fair project or a super tech-head gadget freak; there are enough projects on the single CD-ROM to keep you and 50 of your friends busy for a lifetime!

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FOR BEGINNER GEEKS!

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This lab — from the good people at GSS Tech Ed — will show you 40 of the most simple and interesting experiments and lessons you have ever seen on a solderless circuit board. As you do each experiment, you learn how basic components work in a circuit. Along with the purchase of the lab, you will receive a special password to access the fantastic online interactive software to help you fully understand all the electronic principles. For a complete product description and sample software, please visit our webstore.

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FUNDAMENTALS FOR THE BEGINNER

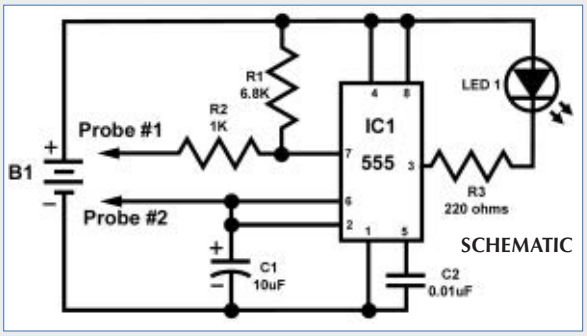
Build a Moisture Detector

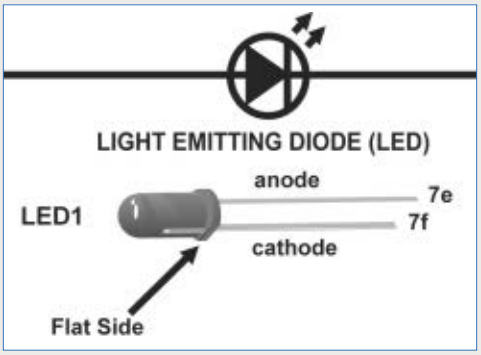
A kit for these experiments can be purchased from the *Nuts & Volts* Webstore at www.nutsvolts.com or call us at 800-783-4624.

If you'd like to test plant soil for moisture, you can use this circuit to do so. The more moisture there is, the faster the LED will blink.

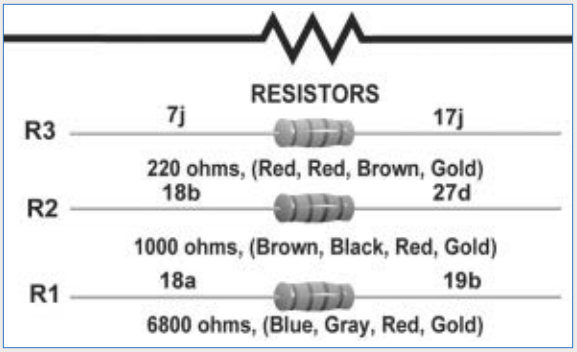
Build the Circuit. Using the schematic along with the pictorial diagram, place the components on a solderless breadboard as shown. Verify that your wiring is correct.

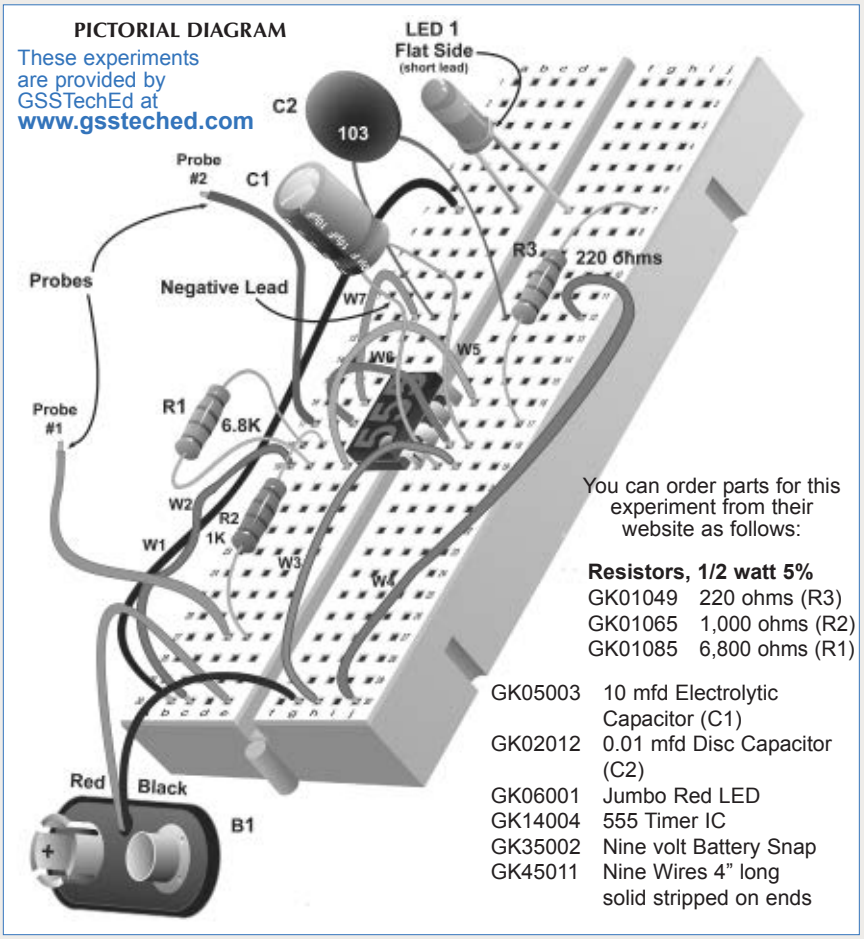
Do the Experiment. Theory: We are using the 555 timer IC as a clock with the frequency controlled by the amount of resistance between the probes. The lower the resistance, the more blinks per second. By experimenting with different soils, you will get used to reading the results. With practice, you will be able to tell the approximate amount of moisture by observing the blinking LED.





Procedure: Connect a nine volt battery to the battery snap and observe that the red LED may or may not be on. If you touch the probe wires together or put them into water, the LED will blink. The more moisture, the faster the blinking.



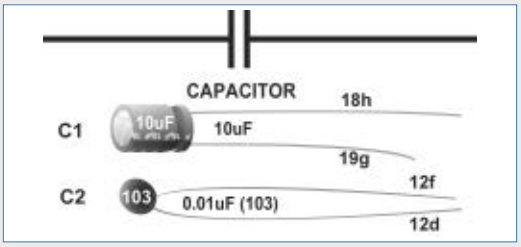


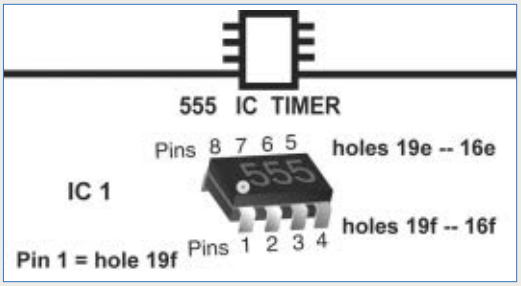
You can order parts for this experiment from their website as follows:

Resistors, 1/2 watt 5%

GK01049	220 ohms (R3)
GK01065	1,000 ohms (R2)
GK01085	6,800 ohms (R1)

GK05003	10 mfd Electrolytic Capacitor (C1)
GK02012	0.01 mfd Disc Capacitor (C2)
GK06001	Jumbo Red LED
GK14004	555 Timer IC
GK35002	Nine volt Battery Snap
GK45011	Nine Wires 4" long solid stripped on ends



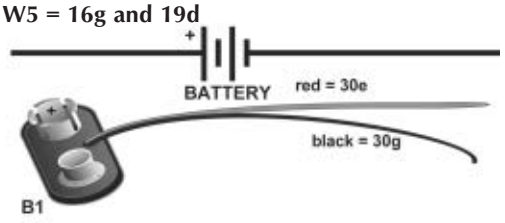


WIRES

W1 = 7b and 30b
W2 = 19a and 30c
W3 = 19h and 30h
W4 = 12j and 30j
W5 = 16g and 19d
W6 = 17d and 18g
W7 = 16d and 12c

PROBE WIRES

Probe #1 in hole 27c
Probe #2 in hole 17a



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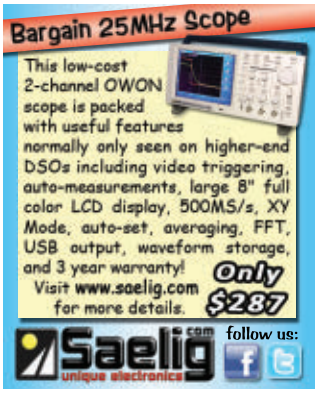
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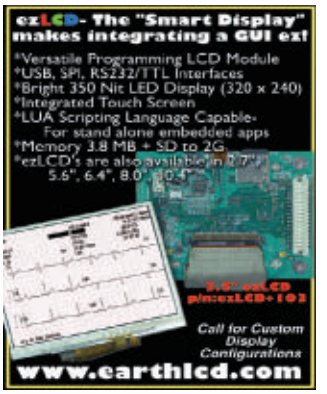
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>>> QUESTIONS

Wire Termination

What connectors seem to be the choice of electronics hobbyists when assembling electronics projects on perf board? Also, is there a standard regarding the spacing of the "perfs" on the boards?

#2121 Don Henderson
Tewksbury, MA

Capacitors

I found hundreds of caps inside a broken computer I've taken apart, but have no idea what they are all used for. I know that they store energy, however, I want to hear what you can do with them.

Is it just timing and smoothing? I'm looking to create circuits, and am puzzled by them.

#2122 Wesley La Ferriere
Madison, NJ

Tools

I'm just getting started in electronics and need advice on what kinds of tools I should get to make my projects easier.

#2123 Wesley La Ferriere
Madison, NJ

Two AC Switches, One Fan

I have two different bathroom vents going into the same exhaust fan. I want to sense either or both switches to access the main relay to run the fan (kind of like an OR gate which I can make from logic gates for DC).

However, my situation calls for AC switches and fans, and I cannot think of a way without converting to DC to be able to switch the AC (long way around).

Is there a simple solution using two 110 VAC switches to turn on the exhaust fan, and then off when both switches are off?

#2124 Raj
Fairfax, VA

Home Intercom System

I would like to put together an intercom system for my house. I want to be able to connect multiple stations, perhaps up to 10 or 12. I'd like to use twisted pair wiring, not shielded wire (for example, existing two pair telephone or four pair CAT 5). I would like to use a central power supply rather than individual batteries or power supplies. I don't need hands-free operation, so a simple push to talk function would be fine, and I'm not concerned about privacy, so when one station is talking, all stations would hear the conversation.

I've seen some two station circuits using LM386 but I can find nothing about creating a multi-station system.

#2125 Terry Palmer
via email

RF Security Fence

I have buried two insulated wires about a foot apart and maybe six inches deep around the perimeter of my yard.

The idea is for a security *fence* that will detect people/animals/cars.

The theory is one wire transmits the RF signal, while the other is a receiver. Any change in signal (and some PIC processing) will flag an intruder.

I can't get it to work. Has anyone tried this and/or can offer any advice?

#2126 Frederick M. Raposa
Vallejo, CA

What's Up With 10- or 12-bit Scopes?

Why is it such a problem for "stand-alone" scope manufacturers to use 10- or 12-bit A/D converters?

I have seen a few PC-based 10-bit units and a 12-bit one, as well. (They do it.)

There is a flood of inexpensive scopes even at the 200 MHz range (with all kinds of bells and whistles).

No way will I even consider upgrading my 20 MHz, eight-bit scope until I get more vertical resolution.

Any thoughts?

#2127 Frederick M Raposa
Vallejo, CA

DC Reducer 48V to 12V

I need a simple breadboard circuit to reduce 48 VDC to 12 VDC. I was able to create one, but did not have enough wattage to support my 12V lights and radio. I know I will need a heatsink, but any other help would be appreciated.

#2128 Bill Fitzpatrick
Pepperell, MA

Audio Electronics

I want to construct an audio amplifier which will have a USB input for audio songs.

Previously, I have constructed many audio systems, but now I want to add USB input where I can get songs just by pluging in a USB stick or memory card.

#2129 Sohail Anjum
Islamabad, Pakistan

>>> ANSWERS

[#12112 - December 2011] Pump Shut-off Needed

There is an electric pump on our boat that moves diesel fuel from one of four main fuel tanks to a day tank to

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Always use common sense and good judgment!

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*Check at **www.nutsvolts.com** for tips and info on submitting to the forum.*

run the engine. It can sometimes take up to 20 minutes to fill the day tank. Sometimes, we forget the toggle switch is on and the tank overflows through the vent line onto the deck. I need to devise a way to automatically turn off the pump when the tank is full, or at least after a specified interval of 5 to 10 minutes. There is no access for a float switch in the tank. Maybe some sort of timer circuit?

This problem is easily solved with a "spring timer."

This is a spring driven 120 VAC switch available at Home Depot, Lowe's, or an electrical supply house. Often used to turn lights out in store rooms or laundry rooms automatically when not needed, it is a spring driven electric switch that fits inside a standard electrical box and is available in various maximum times such as one hour or 15 minutes.

To operate, one twists a knob to the amount of time needed, the load comes on, then goes off when the time runs out.

S/V Bandersnatch
Lying Julington Creek, FL

[#12113 - December 2011] Schematics Needed

Conar Model 251 Oscilloscope

I need a schematic or manual for the Conar model 251 oscilloscope which Conar, I understand, was bought out by NRI/National Radio Institute/McGraw Hill. This is an old single channel 10 MHz analog scope. I need the manual to repair the scope. I already know the power supply works and the cathode ray tube works since I see a momentary dot when the scope is turned off. I am on limited income but will be willing to pay for a copy of the schematic or manual for this scope.

#1 You might check out **www.W7FG.com** (Vintage Manuals).

Terry WB6TA
via email

#2 Try this site for your Conar 251 info: **www.industrycommunity.com/ee/ee-2-next3/messages/203.html**

John Mastromoro
via email

[#1125 - January 2012] Yagi Antenna Question

I live where cellular reception is poor, and I depend on a cellular modem, amplifier, and Yagi antenna

DimensionEngineering
Sabertooth 2x60
Dual 60A Continuous
Brushed Motor Controller
Specifications:
- 60A Continuous, 120A peak current
- 6V - 33.8V input voltage range (8s lipo max)
- Analog, RC (PWM), and Serial Interface
- Overcurrent, overvoltage, undervoltage, and overheat protection built in
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- DEScribe Software Suite Compatable
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$189.99
www.dimensionengineering.com/Sabertooth2x60.htm · 899 Moe Dr. #21 Akron, OH 44310 · 330-634-1430

The Standard for checking Capacitors in-circuit
Good enough to be the choice of Panasonic, Pioneer, NBC, ABC, Ford, JVC, NASA and thousands of independent service technicians.
Inexpensive enough to pay for itself in just one day's repairs. At $229, it's affordable.
And with a 60 day trial period, satisfaction guaranteed or money-back policy, the only thing you can lose is all the time you're currently spending on trying to repair all those dogs you've given up on.
CapAnalyzer 88A
Locate shorted or leaky components or conditions to the exact spot in-circuit
Still cutting up the pcb, and unsoldering every part trying to guess at where the short is?
$229
Your DVM shows the same shorted reading all along the pcb trace. LeakSeeker 82B has the resolution to find the defective component. Touch pads along the trace, and LeakSeeker beeps highest in pitch at the defect's pad. Now you can locate a shorted part only a quarter of an inch away from a good part. Short can be from 0 to 150 ohms.
LeakSeeker 82B
Available at your distributor, or call 561-487-6103
Electronic Design Specialists
www.eds-inc.com

(Wilson Electronics 301111) mounted on our chimney for an Internet connection. In the summer it works pretty well, but in the rainy winter, the signal deteriorates significantly and our connection speed drops. If we're using the fireplace, and the weather dries out for a few days, the signal improves. However, if it's rainy but we're not using our fireplace for a few days, the signal also improves.

My best guess as to the reason is that the combination of smoke from our fireplace and moisture from rain or dew are coating the antenna with a film that is conductive enough to create a partial short across elements of the antenna, causing some attenuation of the signal. The antenna is mounted about six or seven feet above the chimney cap, and it's not really practical to mount it higher without going to a much more complicated mast setup with guy wires.

I'd like to know if I can spray some insulating coating on the Yagi antenna that will prevent the film contacting the conductive parts of the antenna, but that also will not in itself attenuate the signal. Something like WD-40 might work for a while – causing water to just run off – but I want something more permanent, like maybe liquid tape that hardens into a rubbery coating. I just don't know if that type of coating might in itself attenuate the signal.

Does anybody have any advice on how I could seal my antenna without attenuating the signal by an appreciable amount? I'm also open to other ideas, except to go to a different connection technology (DSL isn't available, T1 is too expensive, satellite is worse than what we've got now).

#1 I think you should look at the connectors. They may not be water tight!

Electrical duct butter, electrical duct seal, and coax seal can all be used to encapsulate the connector and socket area to seal it from water inclusion.

I've used Beam antennas up in the air for decades with good results.

B. Jim Russell N4ICU
via email

#2 It sounds like you have a faulty cable and/or cable connector at the antenna. I would replace the cable with Wilson 400 low-loss cable, and put a boot on the connection at the antenna to keep out moisture.

Additionally, the Wilson 301111 Yagi is quite directional; try aiming.

If it has been several years since you installed the antenna, maybe more cell towers have been built in your area.

wave2003
via email

#3 I suggest you try wrapping the elements of your Yagi antenna with PVC electrical tape. It might protect the antenna enough to provide the necessary improvement. As a young "shop gopher" in a two-way r adio shop, I earned many hours of minimum wage wrapping two-way base station antennas with electrical tape. The owner of the shop insisted it reduced received noise and extended the life of the antenna.

Don Pitchford W9EBK
via email

#4 Yes, fire makes carbon smoke a conductive. I'd try a plastic bag to see if it corrects it. Or, place a shield one foot under the antenna.

Richard E. Lenker
via email

If you have a question you'd like our readers to address, email it to **forum@nutsvolts.com** or use the convenient online form at **www.nutsvolts.com**

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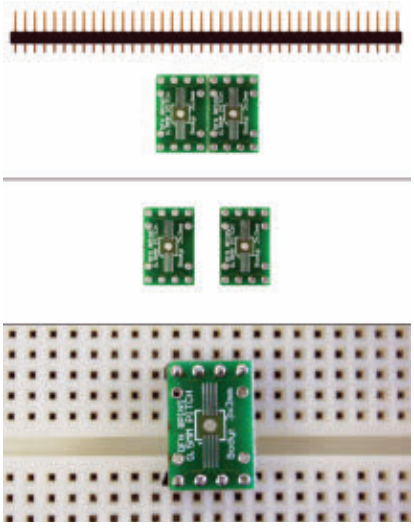
continued from page 31

Detailed knowledge of TCP/IP is not needed. Simple eight-bit micros immediately have much more power since they no longer have the burden of TCP/IP protocols. TCP-offload improves overall system performance, reduces cost, power, and size.

The WIZ820io Ethernet-LAN module is available now for $19.95 each.

For more information, contact:
Saelig Company
Web: **www.saelig.com**

SMT COMPONENTS ON A BREADBOARD



SchmartBoard has expanded its product offering with a new family of products that support the use of Surface-Mount Technology (SMT) components with breadboards. Schmartboard has released two new SMT to DIP adapters that use the patented "ez" technology which makes soldering surface-mount components simple.

"We have hit a real need with this line," says Neal Greenberg, SchmartBoard's VP of Sales and Marketing. "This has been our fastest growing family of products in the few months that we have been marketing it. The reason is that many users are in a quandary because they still need

to use a breadboard and in many cases, only surface-mount components are available."

The two new boards support DFN devices. Part number 204-0021-01 gives you the ability to use two eight lead, .5 mm pitched DFN components. Part 204-0022-01 supports two 10 lead, .5 mm pitched DFN components. The suggested retail price on each of these new products is $6.

For more information, contact:
SchmartBoard
Web: **www.schmartboard.com**

SURFACE-MOUNT INDUCTOR RL-9580 SERIES

As more details of our lives are converted into digital formats,

demand for computing devices and network systems will continue to rise. With critical information (i.e., medical health records) now available in electronic form, professionals and individuals require their devices and networks to be secure and reliable. With this in mind, Renco Electronics has released its newest surface-mount inductor: the RL-9580 Series.

The RL-9580 features sturdy assembly and the capacity to work at extremely high temperatures, allowing for reliable functioning even in arduous environments. This surface-mount also handles high transient current spikes without saturation. In addition, the RL-9580 can operate at high frequencies up to 5 MHz and its composite construction allows for ultra-low EMI.

The RL-9580 Series is excellent for use in smartphones, desktop and notebook computers, server applications, and high current power supplies. They run in an extremely broad temperature range of -40°C to +130°C, and Renco provides shielded construction for added protection.

For more information, contact:
Renco Electronics
Web: **www.RencoUSA.com**

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NightFire Electronics 9
Ramsey Electronics, Inc. 22-23
Swap My Rigs 31
V-Module 71

BATTERIES/CHARGERS
Cunard Associates 31

BUYING ELECTRONIC SURPLUS
Earth Computer Technologies 29
Jaycar Electronics 51
Weirdstuff Warehouse 31

CCD CAMERAS/VIDEO
Circuit Specialists, Inc. 82-83
Matco, Inc. 31
Ramsey Electronics, Inc. 22-23

CIRCUIT BOARDS
AP Circuits 36
Cunard Associates 31
Digilent 21
Dimension Engineering 79
ExpressPCB 20
Front Panel Express LLC 37
PCB Pool 50
R.E. Smith Inc. 29
V-Module 71

COMPONENTS
Anaren 49
Cana Kit Corp. 66
Fun Gizmos 31
NightFire Electronics 9
Noritake 13
V-Module 71

COMPUTER
Hardware
Earth Computer Technologies 29
Noritake 13
Weirdstuff Warehouse 31

Microcontrollers / I/O Boards
Abacom Technologies 36
Bitscope 19
MikroElektronika 3
Fun Gizmos 31
I/O Bridge 13
microEngineering Labs 58
Parallax, Inc. ....Back Cover
Pololu Robotics & Electronics 4

DESIGN/ENGINEERING/ REPAIR SERVICES
Cana Kit Corp. 66
ExpressPCB 20
Front Panel Express LLC 37
PCB Pool 50

EDUCATION
BaneBots 8
Bitscope 19
Command Productions 9
Digilent 21
Global Specialties 7
GSS Tech Ed 71
I/O Bridge 13
NKC Electronics 31
Poscope 49

EMBEDDED TOOLS
NetBurner 2

ENCLOSURES
Front Panel Express LLC 37

KITS & PLANS
Cana Kit Corp. 66
Earth Computer Technologies 29
GSS Tech Ed 71
Jaycar Electronics 51
NetBurner 2
NightFire Electronics 9
NKC Electronics 31
QKITS 31
Ramsey Electronics, Inc. 22-23

MISC./SURPLUS
All Electronics Corp. 67
Front Panel Express LLC 37
Weirdstuff Warehouse 31

MOTORS
BaneBots 8

OPTICS
Noritake 13

PROGRAMMERS
MikroElektronika 3
microEngineering Labs 58

PROTOTYPING & TRAINERS
Global Specialties 7

RF TRANSMITTERS/RECEIVERS
Abacom Technologies 36
Anaren 49
Matco, Inc. 31
Swap My Rigs 31

ROBOTICS
BaneBots 8
Digilent 21
Fun Gizmos 31
GSS Tech Ed 71
Lemos International Co., Inc. 13
Lynxmotion, Inc. 29
Pololu Robotics & Electronics 4

SATELLITE
Lemos International Co., Inc. 13

SECURITY
Matco, Inc. 31

TEST EQUIPMENT
Bitscope 19
Circuit Specialists, Inc. 82-83
Dimension Engineering 79
Electronic Design Specialists 79
Global Specialties 7
HAPRO Electronics 5
Jaycar Electronics 51
NKC Electronics 31
Pico Technology 28
Poscope 49

TOOLS
MikroElektronika 3
NetBurner 2
PanaVise 37

WEB SERVICES
I/O Bridge 13

WIRE, CABLE, & CONNECTORS
Swap My Rigs 31

WIRELESS PRODUCTS
Anaren 49

Abacom Technologies 36
All Electronics Corp. 67
Anaren 49
AP Circuits 36
BaneBots 8
Bitscope 19
Cana Kit Corp. 66
Circuit Specialists, Inc. 82-83
Command Productions 9
Cunard Associates 31
Digilent 21
Dimension Engineering 79
MikroElektronika 3
Earth Computer Technologies 29
Electronic Design Specialists 79
ExpressPCB 20
Front Panel Express LLC 37
Fun Gizmos 31
Global Specialties 7
GSS Tech Ed 71
HAPRO Electronics 5
I/O Bridge 13
Jaycar Electronics 51
Lemos International Co., Inc. 13
Lynxmotion, Inc. 29
Matco, Inc. 31
microEngineering Labs 58
NetBurner 2
NightFire Electronics 9
NKC Electronics 31
Noritake 13
PanaVise 37
Parallax, Inc. ....Back Cover
PCB Pool 50
Pico Technology 28
Pololu Robotics & Electronics 4
Poscope 49
QKITS 31
Ramsey Electronics, Inc. 22-23
R.E. Smith Inc. 29
Swap My Rigs 31
V-Module 71
Weirdstuff Warehouse 31

Programmable DC Electronic Load 0~80V / 0~40A

The 3721A Programmable DC Electronic Load provides excellent performance with sophisticated features found on much more expensive units. This 400 watt, 40 Amp, 0~80 volt Programmable DC Electric Load can be used to test all sorts of DC power sources including power supplies and is especially helpful to battery manufacturing processes. This DC load features constant voltage, constant resistance, constant current and constant power settings. The end user can design programs that control precisely all of the load values and time durations for each step of a test sequence. Up to nine 10 step programs can be internally stored in the 3721A Programmable DC Load.

4 basic functions: CC, CV, CR & CP

8 basic test modes: CCL, CCH, CV, CRL, CRM, CRH, CPV & CPC

Minimum operating voltage is less than 0.6v at the load's full rated current.

High-speed sequence, high-speed transient, short circuit, battery discharge and other functions.

Programable current slew rate.

Multiple groups of parameters and lists can be saved & recalled.

Supports SCPI and LabView with included software.

Current Rating: **0~40A**

Voltage Rating: **0~80V**

Power Rating: **400W at 40°C**

Item#
CSI3721A **$720.00**

www.CircuitSpecialists.com/CSI3721A

Programmable DC Electronic Loads

Thease devices can be used with supplies up to 360VDC and 30A. It features a rotary selection switch and a numeric keypad used to input the maximum voltage, current and power settings. These electronic DC loads are perfect for use in laboratory environments and schools, or for testing DC power supplies or high-capacity batteries. It also features memory, and can also be connected to a PC, to implement remote control and supervision.

360V/150W (CSI3710A) $349.00
www.circuitspecialists.com/csi3710a

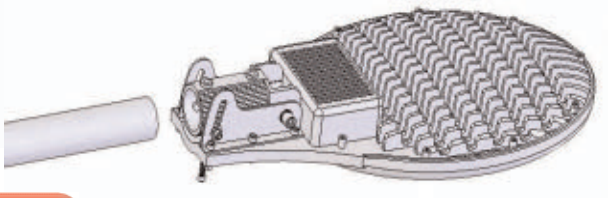
360V/300W (CSI3711A) $499.00
www.circuitspecialists.com/csi3711a

9,000 Lumen 120 Watt Outdoor LED Light

This is a powerful outdoor LED light that provides 9,000 lumens (luminous flux) using just 120 watts of power! Ideal for narrow or wide streets, parking lots and industrial sites. 9,000 lm using just 120 watts od power! The housing is made from cast aluminum and meets IP (Ingress Protection) code 66 (dust tight, no ingress of dust: water tight, water from heavy seas or water projected in powerful jets shall not enter the housing in harmful quantities). The LED glass lens is made from high quality borosilicate glass which is the same substanced used in high quality DSLR lenses and telescopes. This lens material was chosen because of its low coefficient of thermal expansion and ideal refractive index properties.

FEATURES:

* Easy drop-in replacement and installation in place of an existing traditional street light and/ or flood lights
* Built-in power supply (PSU)
* Adjustable armature angle mechanism accomodates various lighting requirements
* Flexible mounting features allow for use as parking lot lights. industrial site lighting, Even inside warehouse lighting
* Compatible with commone AC street lamp power sources: AC input 100-240VAC, 50/60Hz
* Color Temperature: Similiar to daylight (6000 Kelvin)
* Water & dust proof complying to IP 66 (International Protection Rating)
* Designed with integrated cooling fins to maintain constant and stable operating temperature
* Applications: Parking lots, parking garages, basketball courts, sports courts, tennis courts, pool decks, BBQ decks, back yards, apartment complexs, recreation areas, side streets, main roads, and all sorts of outdoor lighting applications.
* Approx Dimensions: 660mm lengh x 360mm width x 100 mm thick



Item#
LED LIGHT **$369.00**

Easily mounted to a standard 2.5" diameter light pole.

Get full specifications at:
www.CircuitSpecialists.com/led-light

60 Watt Digital Soldering Station

For use with traditional or Lead Free Soldering

This is a terrific soldering station featuring a microprocessor controlled temperature set up system with great versatility. The unit includes 3 preset temperature settings that are user definable so you can turn on the system & push one button to go to the temperature range you desire. Specific system temps can also be set with an easy to use push button up/down button AND when you turn off this station, the unit keeps the last used temperature in memory & automaticly returns to that setting the next time the user turns the system on. The temperature display can be set to display in Celsius or Fahrenheit scale.

The CSI-Station-3DLF is a powerful 60 watt soldering system. The fast heat recovery provided by a 60 watt system like this allows the user to solder both traditional solder and lead free solder. This system features a grounded tip to protect delicate circuits from static charge. Also included is a seperate iron holder. Circuit Specialists stocks a large supply of tips for this station.

Features:

* 60 watt dual core ceramic heater
* 150 to 450 degree Celsius Temperature range
* Versatile easy to read liquid crystal display
* 3 preset & user definable temperature settings.
* Automaticly remembers previous temperature setting
* Display in Celsius or Fahrenheit scale
* 3 foot cord length from station to iron tip
* Broad selection of replacement tips available

Item#
CSI-Station-3DLF **$49.00**

www.CircuitSpecialists.com/CSI-Station-3DLF

Circuit Specialists carries a wide selection of traditional & lead-free soldering equipment, including soldering irons, soldering stations, hot-air rework stations, focused infrared systems, reflow ovens, pre-heating systems, regular and lead-free solder, solder flux, and soldering aids for both thru-hole and surface-mount soldering.

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www.CircuitSpecialists.com/soldering-equipment

We carry a LARGE selection of Power Supplies, Soldering Equipment, Test Equipment, Oscilloscopes, Digital Multimeters, Electronic Components, Metal and Plastic Project Boxes, Electronic Chemicals, PC Based Digital I/O Cards, Panel Meters, Breadboards, Device Programmers, and many other interesting items. Check out our website at: *www.CircuitSpecialists.com*

Best Value, Low Cost Station

CSI-Station1A

Easily our best value in our selection of soldering stations. O.E.M. manufactured just for Circuit Specialists Inc., so we can offer the best price possible! The CSI-Station1A features a grounded tip & barrel for soldering static-sensitive devices and uses a ceramic heating element for fast heat up & stable temperature control.

The control knob is calibrated in Fahrenheit & Celsius (392° to 896°F and 200° to 480°C). One of the nicest features is the high quality comfort grip soldering iron. The iron connects to the station via an easy screw-on connector making iron replacement a snap. The 1 meter length iron cord provides plenty of length for users to set up the station in a convenient location. Another nice feature is the soldering iron holder. Made of rugged aluminum,it is a seperate piece from the main station & allows the user maximum convenience.....you don't have to reach all the way back to the station to store the iron. Yet another feature is the stackable design of the CSI-Station1. The main station is designed for an additional unit to be placed on top of it allowing for space saving placement of the CSI-Station1A. Also included at no additional charge is one user replaceable ceramic heating element so that you will be prepared! Large selection of soldering tips available too.

Item# CSI-STATION1A **$29.95**

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3 Channel Programmable Regulated DC Power Supplies

Check out our new programmable hi preformance 3 channel power supplies. Featuring both USB & RS232 interfaces, Overload Protection, Auto Fan Control, and Series or Parallel Operation. Both units feature a Large LCD display panel with simultaneous output and parameter view and a keypad for control. They are ideal for applications requiring high resolution, multiple output, and automated operation such as in production testing. There are both fine and coarse controls via the shuttle knob and 90 memory settings. Software included.

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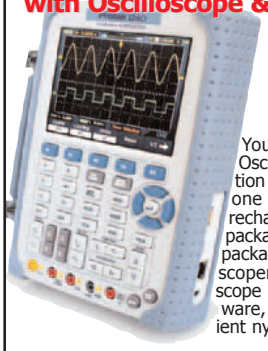

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- 60MHz Bandwidth with 2 Channels
- 150MSa/s Real-Time Sampling Rate
- 50Gsa/s Equivalent-Time Sampling Rate
- 6,000-Count DMM resolution with AC/DC at 600V/800V, 10A
- Large 5.7 inch TFT Color LCD Display
- USB Host/Device 2.0 full-speed interface connectivity
- Multi Language Support
- Battery Power Operation (Installed)

Item # DSO1060 *New Low Price!* **$429.00**

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60MHz Hand Held Scopemeter w/Oscilloscope, DMM Functions & 25 MHz Arbitrary Waveform Generator

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- Waveforms can be saved in the following formats: jpg/bmp graphic file, MS excel/word file
- Can record and save 1000 waveforms
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Model	CSI3644A	CSI3645A	CSI3646A
DC Voltage	0-18V	0-36V	0-72V
DC Current	5A	3A	1.5A
Power (max)	90W	108W	108W
Price	**$199.00**	**$199.00**	**$199.00**

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Introducing the Hantek 5000B Series Digital Storage Oscilloscopes. Available in 60MHz, 100MHz and 200MHz Bandwidths. Each one provides real-time sample rates up to 1GSa/s and equivalent sample rates up to 25GSa/s. In addition, they have a maximum 1M memory depth for better observation of waveform details. The 7 inch color TFT LCD Display with Windows-style interface and menus provide easy operation.

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The Probe Check Wizard guides you to adjust the probecompensation and set the Probe option attenuation factor.

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You can quickly master all functions to greatly improve your efficiency in production and development.

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3 Models to choose from

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Through 40 hands-on activities, you will:

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- Combine several circuits and prototype an invention

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BASIC Stamp Activity Kit - Serial

- Text version 2.2
- USB to Serial Adapter not included

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